WATER AND RELATED LAND RESOURCES
WHITE RIVER BASIN
IN COLORADO

A Report Based on a Cooperative Study by

COLORADO WATER CONSERVATION BOARD

and

UNITED STATES DEPARTMENT OF AGRICULTURE

ECONOMIC RESEARCH SERVICE - FOREST SERVICE - SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
U.S.D.A. FIELD ADVISORY COMMITTEE
COLORADO RIVER BASIN
12417 Federal Building
Denver, Colorado 80202

November 15, 1966

Honorable John A. Love
Governor of Colorado
Denver, Colorado

Dear Governor Love:

The attached United States Department of Agriculture report presents information regarding opportunities for watershed protection, flood prevention and water resource development of the White River Basin in Colorado. It is submitted as a report on participation by the Department of Agriculture in a cooperative survey with the Colorado Water Conservation Board.

This cooperative survey was undertaken in response to a request from the Colorado Water Conservation Board dated March 14, 1963, for cooperation by the Department of Agriculture in such a survey. The Department's part of the cooperative survey included the development and presentation in cooperation with the Colorado Water Conservation Board of the material contained in this report.

Department of Agriculture participation in the survey was under the provisions of Section 6 of Public Law 566, 83rd Congress, as amended, which authorized the Department to cooperate with other Federal, State, and local agencies in making investigations and surveys of the watersheds of rivers as a basis for the development of coordinated programs.

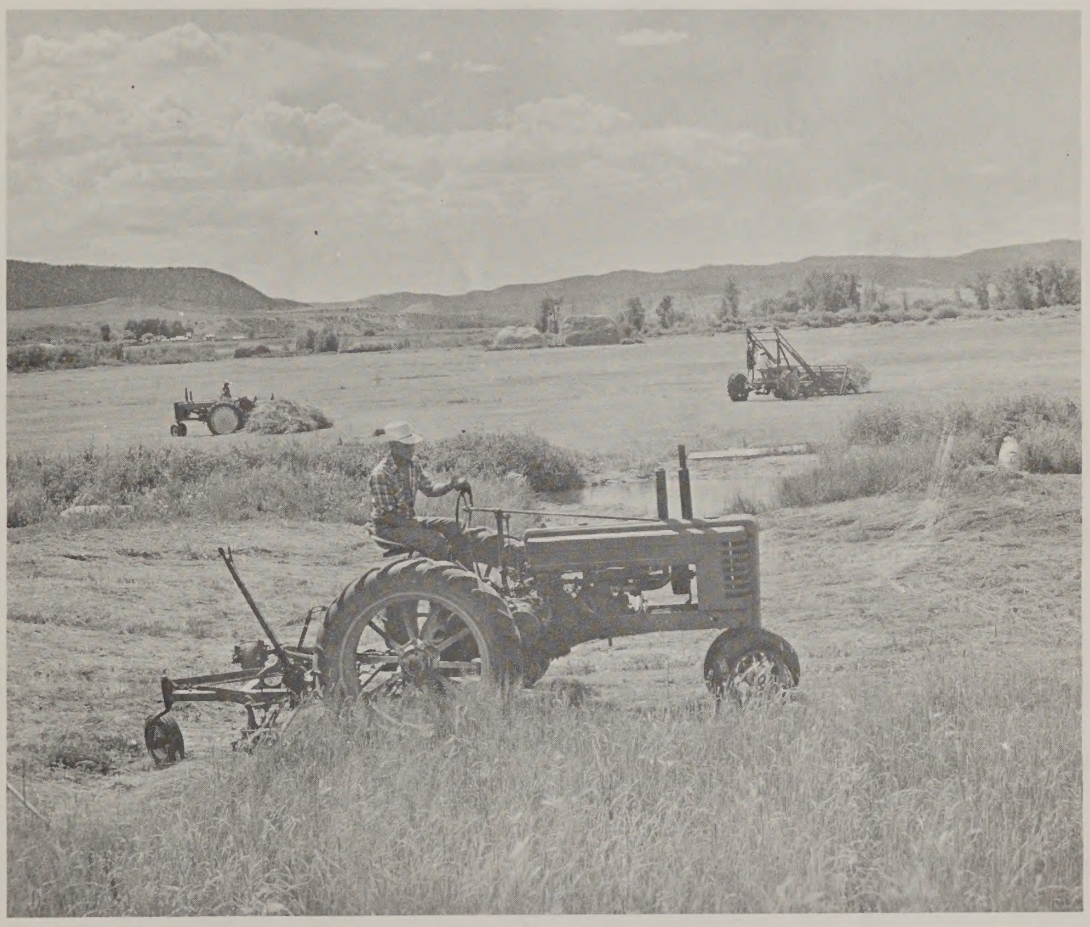
This investigation and survey is coordinated with the study and reports of the Colorado Water Conservation Board relating to the several tributaries of the Colorado River Basin of western Colorado. It presents information obtained from cooperative investigations by the Economic Research Service, Forest Service, and Soil Conservation Service of the Department of Agriculture, and by the Colorado Water Conservation Board of the State of Colorado.

We believe this report of the reconnaissance investigation and survey covers the assignment of the Department of Agriculture as provided in the Plan of Work for the White River Basin study.

Sincerely yours,

F. A. Mark, State Conservationist, SCS
Chairman, USDA Field Advisory Committee

WATER AND RELATED LAND RESOURCES, WHITE RIVER BASIN IN COLORADO



CONSERVATION FARM IN THE WHITE RIVER BASIN

A Report Based on a Cooperative Study by

COLORADO WATER CONSERVATION BOARD

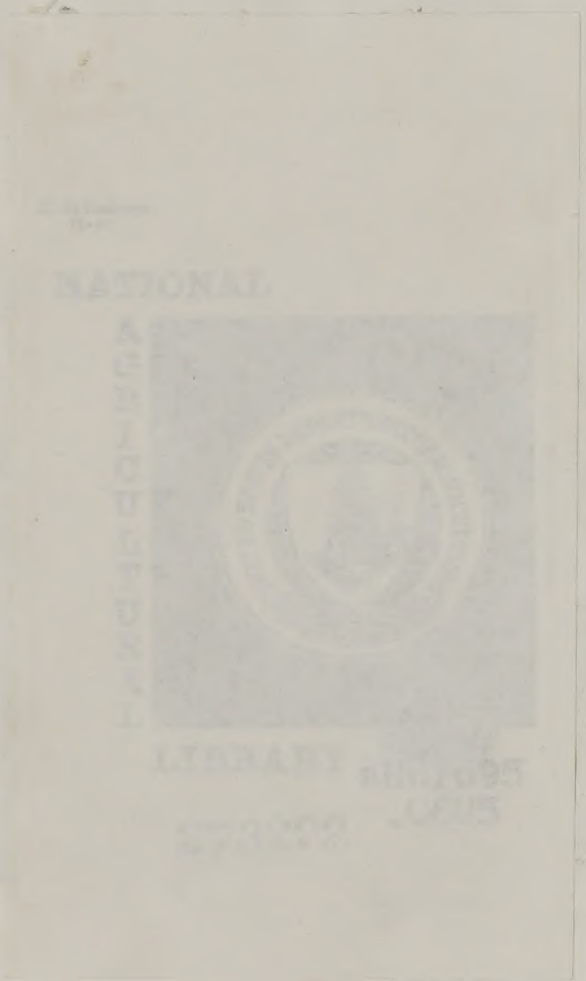
and

UNITED STATES DEPARTMENT OF AGRICULTURE

PREPARED BY

ECONOMIC RESEARCH SERVICE - FOREST SERVICE - SOIL CONSERVATION SERVICE

DENVER, COLORADO – NOVEMBER 1966


NATIONAL
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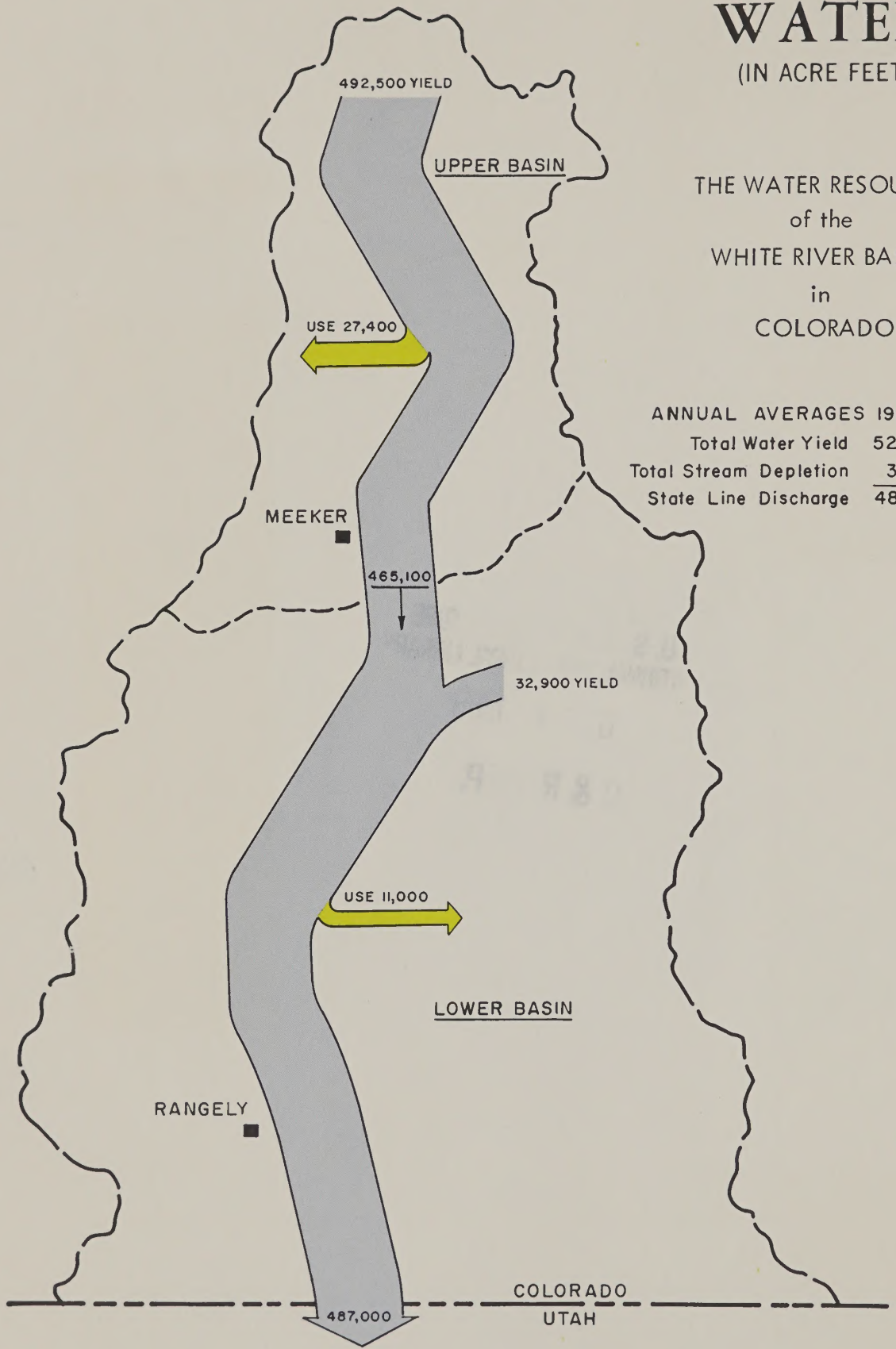
WATER

(IN ACRE FEET)



THE WATER RESOURCE
of the
WHITE RIVER BASIN
in
COLORADO

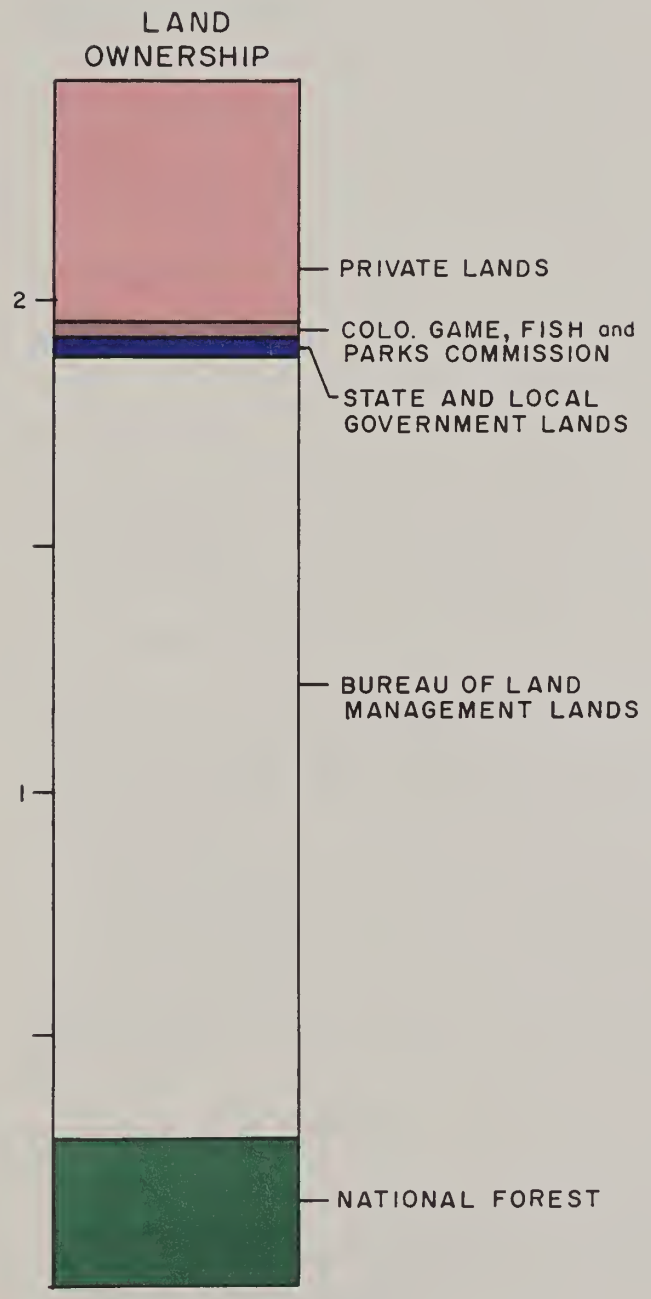
ANNUAL AVERAGES 1943-1960

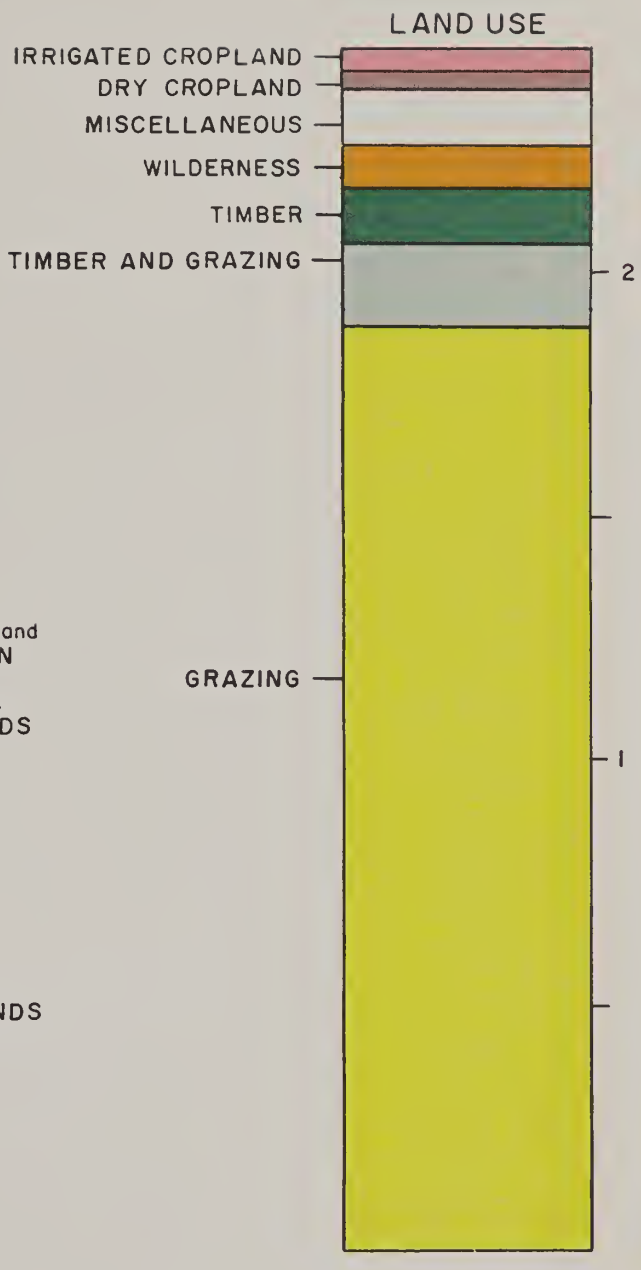
Total Water Yield	525,400 ac.ft.
Total Stream Depletion	38,400 ac.ft.
State Line Discharge	487,000 ac.ft.

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OREG. 1966

M 7-L-18330

LAND
(IN MILLION ACRES)
TOTAL AREA: 2,437,000





THE USE AND OWNERSHIP
of the
LAND RESOURCE
of the
WHITE RIVER BASIN
in
COLORADO

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE USDA-SCS PORTLAND, OREG. 1966

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SUMMARY

This report presents information on the water and related land resources of the White River Basin in Colorado. It is based on a cooperative study by the Colorado Water Conservation Board and the U. S. Department of Agriculture. Participation by the Department of Agriculture was authorized under provisions of Section 6 of Public Law 566, 83rd Congress, as amended and supplemented.

The Basin encompasses 3,808 square miles--about 4 percent of the State of Colorado. Elevations range from 5,000 to 12,000 feet above sea level. Average annual precipitation varies from less than 9 inches to more than 30 inches. Average annual frost-free period for cropland varies from less than 50 days to about 124 days.

Seventy-seven percent of the land is in Federal ownership, 21 percent is privately owned, and 2 percent is owned by State and local governments. Less than 3 percent of the land is used for crop production. The remaining 97 percent is used for grazing, timber production, wilderness, watershed, recreation, and other purposes (Land Resource Frontispiece). Extensive oil-shale deposits constitute an undeveloped natural resource of great economic potential.

The Basin is sparsely populated. The 1960 population was 5,560. Population increased more than 80 percent between 1940 and 1960, primarily as a result of oil and gas development. Projected population based on development of coal for power and the shale-oil industry is 20,000 by 1980, 186,000 by the year 2000, and 204,000 by 2020.

The average irrigated acreage during the 1943-60 period was 35,200 acres. Dry cropland occupied 34,100 acres. An estimated 23,600 acres has a potential for being developed for irrigation, part from present dry cropland acreage. Projection of irrigated and dry cropland acreages are 52,150 and 27,000 respectively for 1980, 50,150 and 25,000 for the year 2000, and 47,600 and 24,000 for 2020.

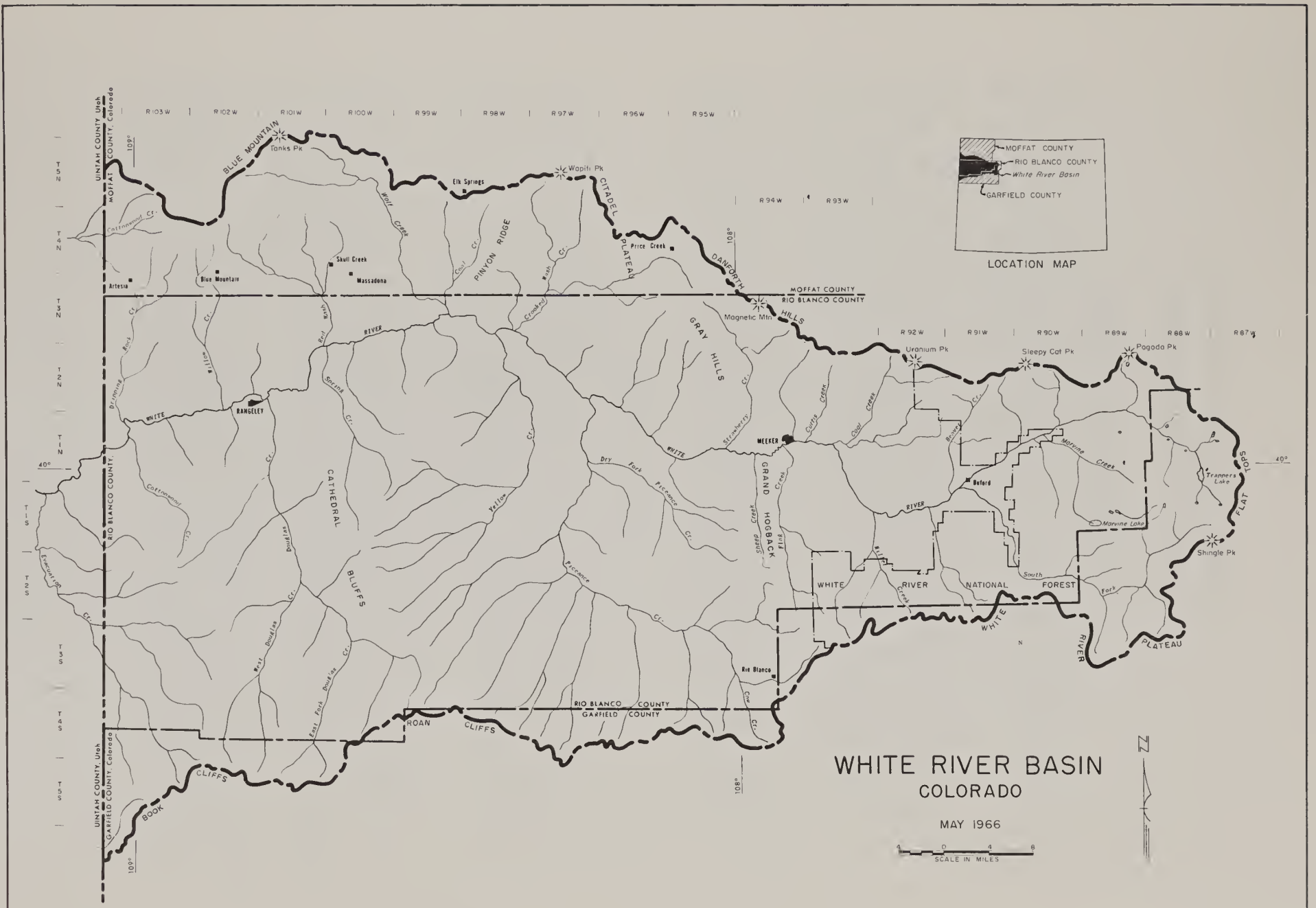
Livestock production dominates the agricultural industry of the Basin. All cropland is devoted to production of feed and forage crops, with the exception of about 6,500 acres used for wheat production and a small acreage of other crops. The 1959 Census of Agriculture showed 27,000 cattle and 63,000 sheep and lambs in the Basin. Rangeland provides 282,300 animal unit months of grazing and irrigated pastures and croplands 65,500. Total agricultural income from sale of farm products was about $3,300,000 in 1959; of this, the sale of livestock and livestock products amounted to about $3,000,000.

The Basin is a recreation area of regional significance. Hunting, fishing, guest ranches, and resorts constitute the principal recreational activities. Tourist use of hotels, motels, and campground facilities amounted to 68,500 visitor-days in 1963. Guest ranches and resorts provided another 1,650 visitor-days. Hunting and fishing in this Basin provided about 175,000 activity days of outdoor recreation in 1963.

The average annual undepleted water supply [1/] for the 1943-60 period was 525,400 acre-feet, average annual depletion was 38,400 acre-feet, and average annual discharge at the Colorado-Utah State line was 487,000 acre-feet (Water Resource Frontispiece). The major use of water was for irrigation. With projected developments, estimated total depletions will be 97,700 acre-feet by the year 1980, 214,700 acre-feet by 2000, and 214,100 acre-feet by 2020.

Program coordination is necessary to assure that proposed project and resource development opportunities complement each other and provide for coordinated development of the resources of the Basin. Water resources are adequate to meet water requirements of proposed resource developments outlined in this report, including potential municipal and industrial requirements.

[1/] Aggregate natural runoff of the River Basin before diminishment by man-related depletions.



WATER AND RELATED LAND RESOURCES

WHITE RIVER BASIN IN COLORADO

AUTHORITY AND ORGANIZATION

This report presents information on water and related land resources of the White River Basin in the State of Colorado. It is based on a cooperative study by the Colorado Water Conservation Board and the United States Department of Agriculture.

Participation of the United States Department of Agriculture was authorized under provisions of Section 6 of the Watershed Protection and Flood Prevention Act (Public Law 566), 83rd Congress, as amended and supplemented. This authorizes the Department to cooperate with other Federal, State, and local agencies in making investigations and surveys of watersheds of rivers as a basis for development of coordinated programs.

Survey work by the United States Department of Agriculture was carried out by technicians of the Soil Conservation Service, Forest Service, and Economic Research Service under the direction of a USDA Field Advisory Committee, Colorado Basins, composed of representatives of these agencies.

PURPOSE AND SCOPE

Information is presented about water and related land resource use and management which provides a basis for coordinating USDA programs of watershed protection, flood prevention, land and water management, and recreation with related activities of local, State and other Federal agencies. Information is also presented which will provide a basis for development of projects under the Watershed Protection and Flood Prevention Act, Public Law 566, as amended.

This is one of a series of cooperative river basin surveys being conducted on the western slope of Colorado by the U. S. Department of Agriculture and the Colorado Water Conservation Board. Previous studies resulted in reports on Water and Related Land Resources of the Gunnison River Basin (1962) and the Colorado River Basin in Colorado (1965). Similar studies are scheduled for the Yampa, Dolores, and San Juan River Basins.

This study utilized applicable data from previous investigations wherever possible. The report is developed from field surveys and analysis of material collected from many sources. It is presented in the form of an inventory or information document rather than as an action or authorizing report.

For these currently scheduled River Basin Surveys, hydrologic and water supply studies are being standardized to include the years of 1943-60 as a base study period. These years have been selected because of the greater availability of streamflow and other necessary records, and because they include periods of both above and below longtime average stream flows. They are reasonably representative of conditions existing during recent time periods and may be compared with other base periods through applicable statistical or analytical procedures. Where possible, other data within the report have been developed for the same base period; however, there are some instances, such as in recreation, where records are nonexistent or are nonrepresentative of the base period. In these cases, use has been made of existing information regardless of time periods of record availability.

State and Federal agencies in addition to the United States Department of Agriculture and the Colorado Water Conservation Board, have provided data and assistance for this report. Chief contributors are the U. S. Bureau of Reclamation, U. S. Bureau of Land Management, Colorado State Soil Conservation Board, Colorado River Water Conservation District, Upper Colorado River Commission, U. S. Bureau of Census, U. S. Statistical Reporting Service, U. S. Geological Survey, U. S. Weather Bureau, U. S. Federal Water Pollution Control Administration, Colorado Division of Public Works, Colorado Division of Commerce and Development, Colorado Department of Agriculture, the Moffat, Yampa, Douglas Creek, and White River Soil Conservation Districts, and the water user's association and conservancy districts within the area.

GENERAL DESCRIPTION OF THE BASIN

Location and Size

The White River Basin in Colorado is located in west-central Colorado between the Colorado River on the south and the Yampa River on the north. The White River rises in the White River Plateau and flows west to its confluence with the Green River in Utah. The White River Plateau is a high mesa separated from the Continental Divide on the east by the Colorado and Yampa rivers. The Plateau's elevation is generally 10,000 feet with peaks above 12,000 feet. Most of the south boundary of the Basin is the Book and Roan Cliffs which form the divide between the White and the Colorado rivers. The north boundary is the divide that connects a series of peaks and mountains running from Flat Top Mountain through Pagoda Peak, Sleepy Cat Peak, Uranium Peak, Magnetic Mountain, Wapiti Peak, Tanks Peak, Blue Mountain and on to the Utah-Colorado State line. The river basin is approximately 107 miles long and averages 35 miles wide, with a total land area of approximately 3,808 square miles.

History

The White River Basin was part of the home and hunting ground for the Confederated Ute Indian tribes until 1868, when the confederacy was broken into three units. The Utes were a warlike people and white settlement within their domain created many conflicts. The treaty in 1868 provided for an Indian Agency to be established near the present town of Meeker, within the Northern Ute Indian Reservation which included the White River Basin. Colonel Nathan C. Meeker was one of the early-day Indian agents.

Colonel Meeker and eleven others were killed and many whites taken prisoners in the Meeker Massacre that occurred on September 29, 1879. United States military troops quieted the rebellion with the help of Chief Ouray of the Uncompahgre Utes. An Army post known as "Camp on the White River, Colorado" was established after the Meeker Massacre and was maintained until 1883. Military troops moved the Utes to their present reservation in Utah. Settlers were kept from entering the old reservation area until September 4, 1881. Early settlement was on natural meadows located along river valleys or where hay fields or meadows could be irrigated from streams. The town of Meeker grew up around the Army post shortly after 1881 and was incorporated November 4, 1885.

Since early settlement, grazing of livestock on rangeland bordering valley farms and hay ranches has been the principal agricultural operation. Records for the White River National Forest,[1/] Blanco Ranger District, show 26,000 head of cattle and horses in 1907, but no sheep. First sheep grazing on national forest land was in 1911. Since then, sheep and cattle numbers have fluctuated. In 1936, one of the heaviest stocking years, records show that 97,000 head of sheep, 29,377 head of cattle, and 350 head of horses were grazed on national forest land. Grazing controls on public domain began with passage of the Taylor Grazing Act of 1934.

Timber operations date back to 1870 when the government operated a sawmill in connection with the White River Indian Agency.

1/ The White River Plateau Timber Reserve (now White River National Forest) was established October 16, 1891 under the Creative Act of March 3, 1891, by Proclamation of President Benjamin Harrison. Thus, the first "Forest Reserve" in Colorado was established. "Forest Reserves" were transferred from U.S.D.I. to U.S.D.A. in 1905 and their name was changed to National Forests in 1907.

A wind storm in 1939 blew down large amounts of green timber and set the stage for a large scale infestation of Englemann spruce bark beetle. By 1949, most of the readily accessible merchantable Englemann spruce timber on the western slope of Colorado had been destroyed.

Public recreation, especially hunting and fishing, has long been an important activity in the White River Basin. Bighorn sheep, mule deer, and buffalo were numerous. Elk were not reported to be abundant until after the breakup of the Red Desert herd in Wyoming in the late 1890's. Big game animals have a natural migration route through the Basin which has persisted since before white settlement. Deer migrate from Piceance Creek and Douglas Creek watersheds to high national forest lands of the White River Plateau in the spring, where they graze all summer and return to lower elevations in winter. Elk winter in the area near Meeker and graze into the alpine area in the summer.

Fishing has been good within the Basin since early times. Private and public lodges were built and a business of outfitting and guiding hunting and fishing parties developed. John C. Osgood constructed a private lodge at Trappers Lake in 1886 and operated it until 1892. Senator Horatio Henderson Eddy and a group of Colorado Springs residents established Marvine Lodge near the confluence of Marvine Creek and White River, and operated it as a private resort from 1890 to 1896. Guests were brought in by stage, with as many as 150 being accommodated at one time. Extensive subsequent developments have capitalized on the scenic and outdoor recreation resources of the Basin.

Population

About 5,560 people were living in the Basin in 1960 (table 1). More than 90 percent live in Rio Blanco County, with the remainder in Moffat County. Records do not indicate any permanent resident population in the Garfield County part of the Basin. Rio Blanco County population has increased since the county was organized in 1889, except from 1920 to 1940 when there was a small loss in population. There was a significant increase in population after 1940, mostly as a result of the development of oil and gas resources.

Table 1.--Population by counties, White River Basin in Colorado, 1930-60

Counties	1930	1940	1950	1960
	Number	Number	Number	Number
Moffat 1/	190	200	450	450
Rio Blanco 1/	2,880	2,870	4,670	5,110
Garfield 1/	0	0	0	0
Total	3,070	3,070	5,120	5,560

1/ Estimated for portion of county within the Basin.

Source: U. S. Census of Population

The Basin has three main centers of population; Meeker and Rangely in Rio Blanco County and Artesia (changed to Dinosaur in 1964) in Moffat County. The 1960 population of these towns totaled 3,437 or about 62 percent of the total. The towns have continued to grow. In January 1964 Meeker had an estimated population of 1,660, Rangely 1,600 and Artesia 350 making a total urban population of 3,610.

Land Ownership

About 21 percent of the land in the White River Basin is privately owned (table 2). Seventy-seven percent is owned by the Federal government, and about 2 percent by the State of Colorado and local government units. Details of the land ownership pattern are shown on the Land Ownership Map following page 6. A graphic presentation of distribution of land ownership is given on the Land Resource Frontispiece.

Table 2.--Land ownership by counties, White River Basin in Colorado, 1964

County	Private land	State lands: Colo. Game, Fish & Parks Commission	State lands: State and local gov't land	Federal lands: Bureau of Land Management 1/	Federal lands: National Forest 1/	Total
	Acres	Acres	Acres	Acres	Acres	Acres
Garfield	16,900	0	0	96,900	134,600	248,400
Moffat	92,700	0	20,500	222,100	0	335,300
Rio Blanco	390,500	37,500	600	1,204,900	219,800	1,853,300
Total	500,100	37,500	21,100	1,523,900	354,400	2,437,000
Percent	20.5	1.5	.9	62.5	14.6	100.0

1/ Bureau of Reclamation and other withdrawal lands included.

Source: USDA Field Party

The 500,100 acres of private land is generally confined to irrigated and dry farmland and adjacent rangelands. However, there were approximately 35,000 acres of private land that were assessed as oil or oil-shale lands in 1964. In the Piceance Creek area, a major portion of the private land is now owned by large oil companies or their subsidiaries. In the Upper White River Basin non-resident ownership is increasing. Most of this area is used for recreation or summer living. The Colorado Game, Fish and Parks Commission owns 37,500 acres, mostly in the drainage areas of Big Beaver, Piceance, Yellow and Douglas Creeks.

The largest portion of State and local government land is school lands under the administration of the Colorado State Board of Land Commissioners (20,500 acres). This land is in the Moffat County portion of the Basin. Municipalities own the remaining 600 acres.

All of the national forest land is in the White River National Forest. These lands are in the eastern part of the Basin and range from about 8,000 feet to 12,000 feet in elevation. Land administered by the Bureau of Land Management is generally at elevations below 8,500 feet. In the eastern third of the Basin, Bureau of Land Management lands are notably disconnected or in isolated parcels. About 25,100 acres of these lands are not within the boundaries of the Craig District and are commonly referred to as "Section 15 lands". The long range program for these lands include their possible transfer to state or local government for public purposes, or disposal through exchange or public sale. This would materially aid in establishing a more desirable pattern of land ownership. The consolidated public lands in the western two-thirds of the Basin are generally considered to meet the criteria for retention in Federal ownership for Multiple Use Management as provided by the Classification and Multiple Use Act of September 1964.

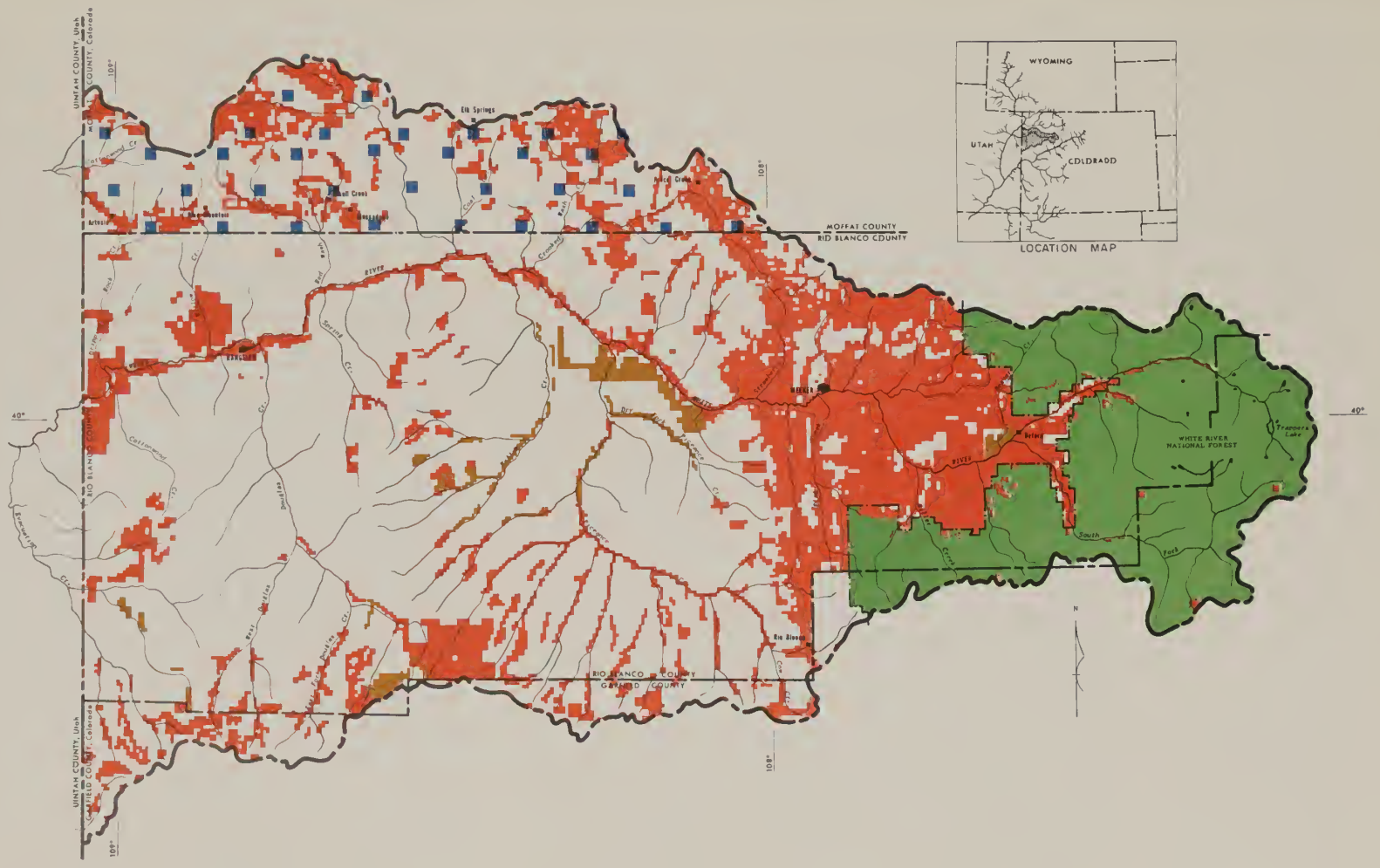
Climate

The climate is highly variable over the Basin, being semi-arid with relatively warm summers and cold winters. Extremes are due largely to the wide range of elevation and exposure. The mean annual temperature at Meeker is about 44°F. with extremes of -43° F. to 103° F.

Average annual precipitation varies from more than 30 inches in upper reaches of the Basin to less than 9 inches at Rangely. Higher irrigated lands above Buford have an annual frost-free period of less than 50 days, while the lower valley near Rangely averages about 124 days.

Seasonal distribution of precipitation is fairly uniform during the year. A little less than half usually occurs during the December-April period as snow. About one-third usually occurs during the irrigation season, though this is variable with respect to location. Accumulation of winter snows is the principal source of stream flow. Summer rainfall generally takes the form of showers that contribute little to over-all water supplies. On higher areas near the eastern edge of the Basin, rainfall is typically mountain thundershower in characteristics, with only limited areas having locally severe intensities. At lower elevations, summer showers are affected by convective conditions and frequently occur in the form of "cloudbursts". Floods are of short duration and low total water production, but peak flows are high.

Evaporation studies have not been carried on in the Basin to any great extent. Data from comparable areas in the State indicate that average evaporation rates would be from about 55 inches in the lower part of the Basin to around 25 inches at the higher elevations.



LOCATION MAP

LAND OWNERSHIP STATUS

LANDS ADMINISTERED BY THE BUREAU OF LAND MANAGEMENT. WITHDRAWALS AND RESERVATIONS PRIMARILY UNDER B. L. M. JURISDICTION AND VACANT PUBLIC LANDS.

PRIVATELY OWNED LAND, PATENTED, R. R., MINING AND SMALL HOLDING CLAIMS, CORPORATIONS, CITIES, ETC.

NATIONAL FOREST LANDS INCLUDING LANDS IN TRUST ADMINISTERED BY THE U. S. FOREST SERVICE

STATE OWNED LANDS, EXCEPT THOSE UNDER CONTROL AND TITLE OF STATE FISH AND GAME DEPARTMENTS.

COLORADO GAME, FISH AND PARKS DEPARTMENT LANDS.

LEGEND

CITIES AND TOWNS

RESERVOIR

BASIN BOUNDARY

COUNTY LINE

STATE LINE

NATIONAL FOREST BOUNDARY

LAND OWNERSHIP MAP
WHITE RIVER BASIN
COLORADO

SCALE 10 0 10 20 MILES

USDA SCS LINCOLN, NEBR 1964

LAND RESOURCES

Physiography

The White River Basin extends across portions of two major physiographic provinces. The eastern one-third lies within the White River Plateau section of the Southern Rocky Mountain province, while the western two-thirds is within the Uintah Basin section of the Colorado Plateau province. Elevations vary from about 5,000 feet, where the White River crosses the Colorado-Utah State line, to 12,000 feet on Shingle Peak among the Flat Tops of the White River Plateau.

Headwaters of the White River are in the White River Plateau, a relatively flat high-lying area that has been moderately dissected by stream erosion and glacial action. While the plateau generally exceeds 9,000 feet in elevation, stream valleys through much of the area are from 1,500 to 2,500 feet lower. In the Flat Tops area, elevations generally are from 10,000 to 11,500 feet. Numerous lakes, mainly of glacial origin, occur throughout the higher parts of the plateau and along the upper reaches of the main valleys. The largest area of open and relatively level land is adjacent to the town of Meeker. The Grand Hogback is a prominent north-south ridge rising 1,500 feet above the surrounding area, and extending from near Meeker to beyond the south boundary of the Basin. It is formed mainly by steeply dipping resistant sandstone beds and marks the western boundary of the White River Plateau.

West of Meeker the Basin comprises an area of diverse topography including dissected lesser plateaus, sharp ridges, abrupt cliffs, and rugged badlands interspersed with open valleys, parks, and basins. The presence of underlying rock layers with wide differences in resistance to erosion has been the principal factor in development of these features. Differential erosion has resulted in the more resistant rock layers standing in relief while broad open valleys have been cut in the softer rocks.

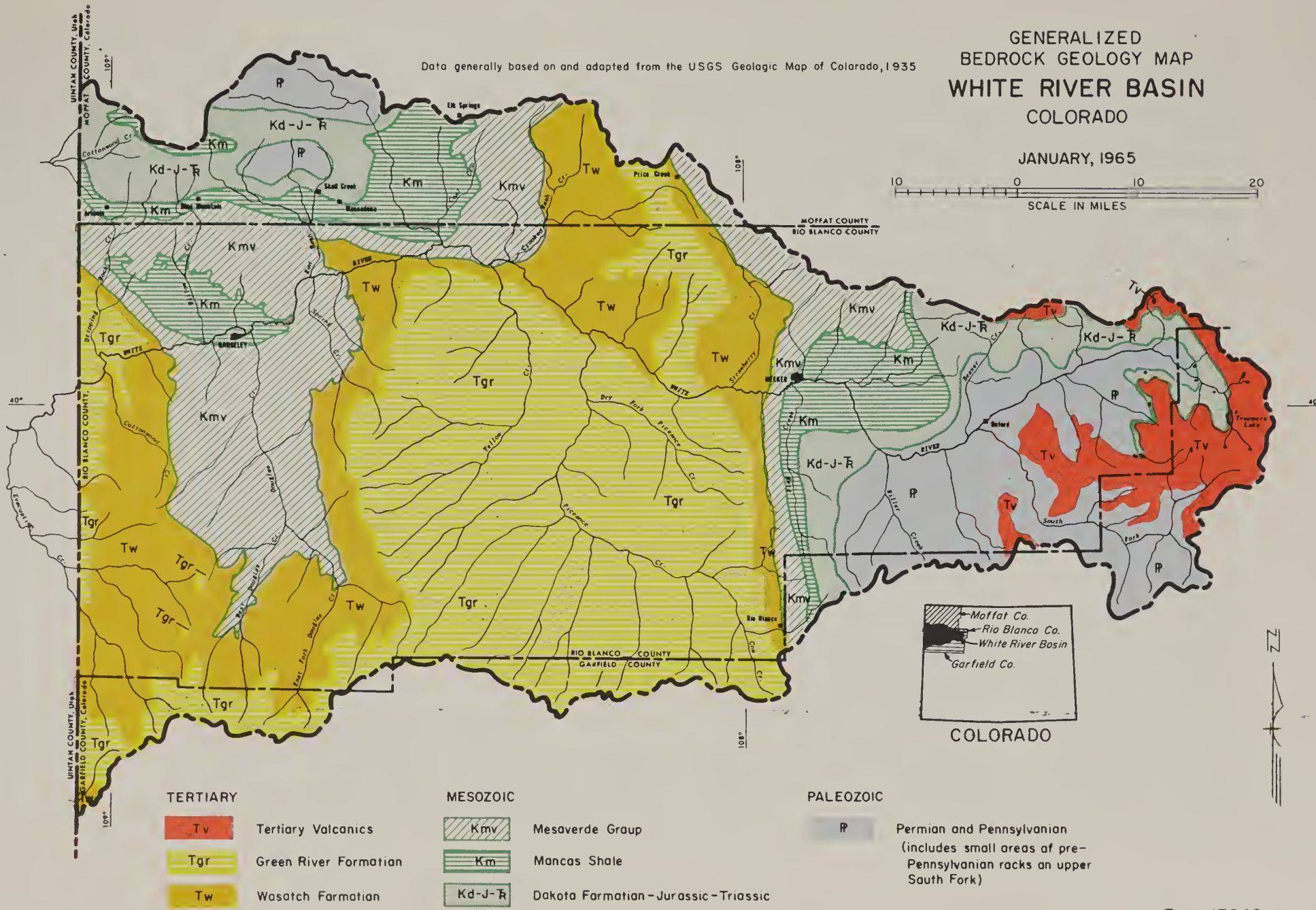
The Roan Plateau is a lightly dissected broad drainage divide that lies along the southern edge of the area within the upper drainage basins of Piceance Creek and Douglas Creek. Elevations vary from about 6,500 feet to over 9,000 feet. The plateau area is characterized by rolling country containing many straight northeast-trending valleys that are mostly less than 300 feet below the general level of the upland surface. Cathedral Bluffs face westward toward the valley of Douglas Creek and trend generally northward. The area along the west face of the bluffs is rugged, with a maximum relief of about 3,000 feet. The area east of the crest of the Cathedral Bluffs slopes gently northeastward towards Piceance Creek.

Cathedral Bluffs

On the north boundary of the Basin, from Meeker westward to the Colorado-Utah State line is an area characterized by broad basins separated by rocky ridges and narrow plateaus. Elevations are from 5,000 to about 8,600 feet above sea level. Bare rock surfaces are common in cliff faces, along dip slopes, and in badland areas. Pedimentation has left some remnants of gravel surfaces lying at relatively high levels above present drainage channels. Stream terraces occur along most major valleys.

Geology

Rocks ranging in age from Precambrian to Quaternary are exposed in the White River Basin (Bedrock Geology Map, following page). Except for small areas of Precambrian crystalline rocks and Tertiary lava flows in the White River Plateau, they consist of a thick sequence of sedimentary rocks of Paleozoic, Mesozoic, and Tertiary age. Areal distribution of these rocks is controlled by three major structural features,


GENERALIZED
BEDROCK GEOLOGY MAP
WHITE RIVER BASIN
COLORADO
JANUARY, 1965
10 0 10 20
SCALE IN MILES
Data generally based on and adapted from the USGS Geologic Map of Colorado, 1935
UINTAH COUNTY, Utah
MOFFAT COUNTY, Colorado
MOFFAT COUNTY
RIO BLANCO COUNTY
RIO BLANCO COUNTY
GARFIELD COUNTY
UINTAH COUNTY, Utah
GARFIELD COUNTY, Colorado
Moffat Co.
Rio Blanco Co.
White River Basin
Garfield Co.
COLORADO
TERTIARY
Tv Tertiary Volcanics
Tgr Green River Formation
Tw Wasatch Formation
MESOZOIC
Kmv Mesaverde Group
Km Mancos Shale
Kd-J-R Dakota Formation - Jurassic - Triassic
PALEOZOIC
P Permian and Pennsylvanian (includes small areas of pre-Pennsylvanian rocks on upper South Fork)
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE USDA-SCS PORTLAND OREG 1965 M-4297
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the White River uplift, Piceance Creek basin, and Douglas Creek arch. These were formed gradually over an interval beginning near the end of the Mesozoic and continuing through the early Tertiary.

The Piceance Creek basin lies across the central part of the White River Basin. It is a broad structural depression which was also the original basin of deposition for early Tertiary sediments. On the east, it is flanked by the White River uplift, a broad dome underlain mainly by rocks of Paleozoic age. On the west, it is flanked by gently-dipping strata of the Douglas Creek arch.

The oldest part of the White River Basin geologically is in the White River uplift. Here the oldest rocks crop out over small areas along the South Fork of the White River. They consist of Precambrian schist and granite overlain by several hundred feet of lower Paleozoic sedimentary rocks including quartzite, sandstone, dolomite, and limestone. However, the largest part of the uplift area is underlain by rocks of Pennsylvanian and Permian age consisting of dark-gray to black shales and gypsum overlain by more than 3,000 feet of red shales, siltstones, sandstones, and conglomerates. Pennsylvanian and Permian rocks are overlain by several hundred feet of alternating beds of shale, siltstone, and sandstone of Triassic, Jurassic, and Lower Cretaceous age. This sequence of rocks includes the Entrada, Morrison, and Dakota Formations and crops out in relatively steep ridges in a narrow belt around the margins of the White River uplift.

Mancos Shale of Upper Cretaceous age has a thickness of more than 5,000 feet. They consist essentially of dark gray calcareous marine shale that weathers light gray to light yellow-brown. Selenite gypsum is common throughout the formation.

The Mesa Verde Group crops out around the margins of the Piceance Creek basin and consists mainly of sandstone with much interbedded shale and several coal beds. These rocks are usually resistant to erosion and often form prominent mesas, ridges, and cliffs. The thickness of Mesa Verde ranges from about 2,500 feet to 5,600 feet.

The Wasatch Formation, which also crops out around the margins of the Piceance Creek basin, consists mainly of red, purple, and gray shale and clay with some sandstone layers. These rocks are relatively erodible and this formation generally forms broad valleys or badland areas between cliffs or ridges of the Green River Formation and the Mesa Verde Group.

The Green River Formation, which crops out over most of the Piceance Creek basin, is composed mainly of light gray to light brown shale and marlstone with some sandstone and limestone. Oil-shale beds occur

throughout the Green River Formation but are thickest in the Parachute Creek Member. The Green River Formation attains a maximum thickness of about 3,500 feet. These rocks are relatively resistant to erosion and generally underlie broad plateaus or mesas that frequently terminate in sheer cliffs.

Basaltic lava flows of late Tertiary age occur over most of the Flat Tops area in the White River Plateau. These rocks have a total thickness of several hundred feet and are composed of several individual flows, which are often separated by thin beds of volcanic ash.

Glacial deposits of Pleistocene age are widespread in the White River Plateau. Moraines representing several intervals of glaciation are present along most of the major valleys in the higher portions of the plateau. Several levels of Pleistocene stream terraces and pediment surfaces underlain by sandy and gravelly deposits occur along the White River and its larger tributaries. Recent alluvium occurs in floodplains of most smaller tributaries and along the larger streams.

Mineral Resources

In 1963, Rio Blanco County ranked second in the State in value of mineral production. The County's 522 wells produced 18.3 million barrels of oil, highest in the State. The County ranked first in natural gas production. Sand, gravel, coal and uranium also are produced.

The Rangely oil field was completely developed by May 1949. Natural gas reinjection and waterflood operations have extended the estimated total production from about 300 million barrels to 700 million barrels of oil. The secondary recovery of oil by waterflood operations began in 1958 and is currently one of the largest operations of this type. The Wilson Creek oil field was discovered in 1937. Located northwest of Meeker at an elevation of about 8,500 feet above sea level, this is the highest oil field in North America and one of the largest producing fields in Colorado.

Since 1950, Rio Blanco County has been the largest producer of natural gas in the State. The peak year was 1957 when more than 69 billion cubic feet were produced. This production was more than four times that of any other county in the State. Some of the gas produced has been used for reinjection in the nearby oilfields for pressurization to extend oil production. Location of the major gas-producing area is in the Piceance Creek drainage and most of the wells yield gas from the Green River and Wasatch Formations.

Operating well in the Rangely oil field

In recent years the value of sand and gravel produced at plants near Meeker and Rangely has outranked the value of uranium and coal produced in the county. Used mainly for construction purposes, sand and gravel serves as an aggregate for concrete, asphalt, mortar, and as road fill. Uranium deposits in the Basin are generally small. A considerable amount of exploration was done in the middle 1950's northeast of Meeker in an area known as Uranium Peak.

Rio Blanco County has not been a large producer of coal. However, increasing demand for electrical energy in the Western States will require increasing amounts of coal as fuel for generating plants. The two major coal fields are Danforth Hills north of Meeker and the lower White River near Rangely. The field in the lower White River is in the Williams Fork Formation of the Mesa Verde Group and available data indicate the presence of large resources of high-volatile bituminous coal. A coal-fired steam generating power plant is tentatively planned near Rangely.

Many authorities agree that domestic petroleum supplies will have to be supplemented with shale oil in order to meet increasing national

demand for petroleum products. The largest known deposits of oil shale in the world are located in western Colorado. They occur in the Green River Formation which underlies the Piceance basin in Rio Blanco and Garfield Counties. A succeeding section of this report discusses in additional detail the oil shale development potential and its probable impact.

Soils

The former systems of soil classification [1] [2] followed in the United States placed all soils in six categories. In descending sequence the six were: order, suborder, great soil group, family, series, and type. Great soil groups alone and in defined associations are sometimes used as map units on general soil maps and that procedure was followed in this report.

In January 1965 a new classification system [3] was adopted for field use by the Soil Conservation Service and agencies participating in the National Cooperative Soil Survey. The new system retains six categories but names and limits are different than those used in the old system. For convenience of the reader, great soil group names of the old and great group names of the new system are shown in estimates of composition for each map unit on the general soil map (following page). Readers requiring detailed information on characteristics of the groups and an explanation of terminology should consult recent publications. [3] [4]

By drawing lines around portions of land with similarities in soil, relief, geology and vegetation it is possible to make a general soil map of the Basin. The different kinds of soil are broadly associated and form patterns which are repeated from place to place.

A general soil map is useful to compare different parts of the Basin or locate soil having general similarities and suitability. The broad characteristics and relationships show in a general way the potential of the soils for agricultural, industrial and commercial uses.

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[1] Baldwin, Mark, Kellogg, Charles E., and Thorp, James "Soil Classification," USDA yearbook, 978-1101, 1938.

[2] Thorp, James T., and Smith, Guy D. "Higher Categories of Soil Classification; Order, Suborder, and Great Soil Groups." Soil Sci. 67:117-126, 1949.

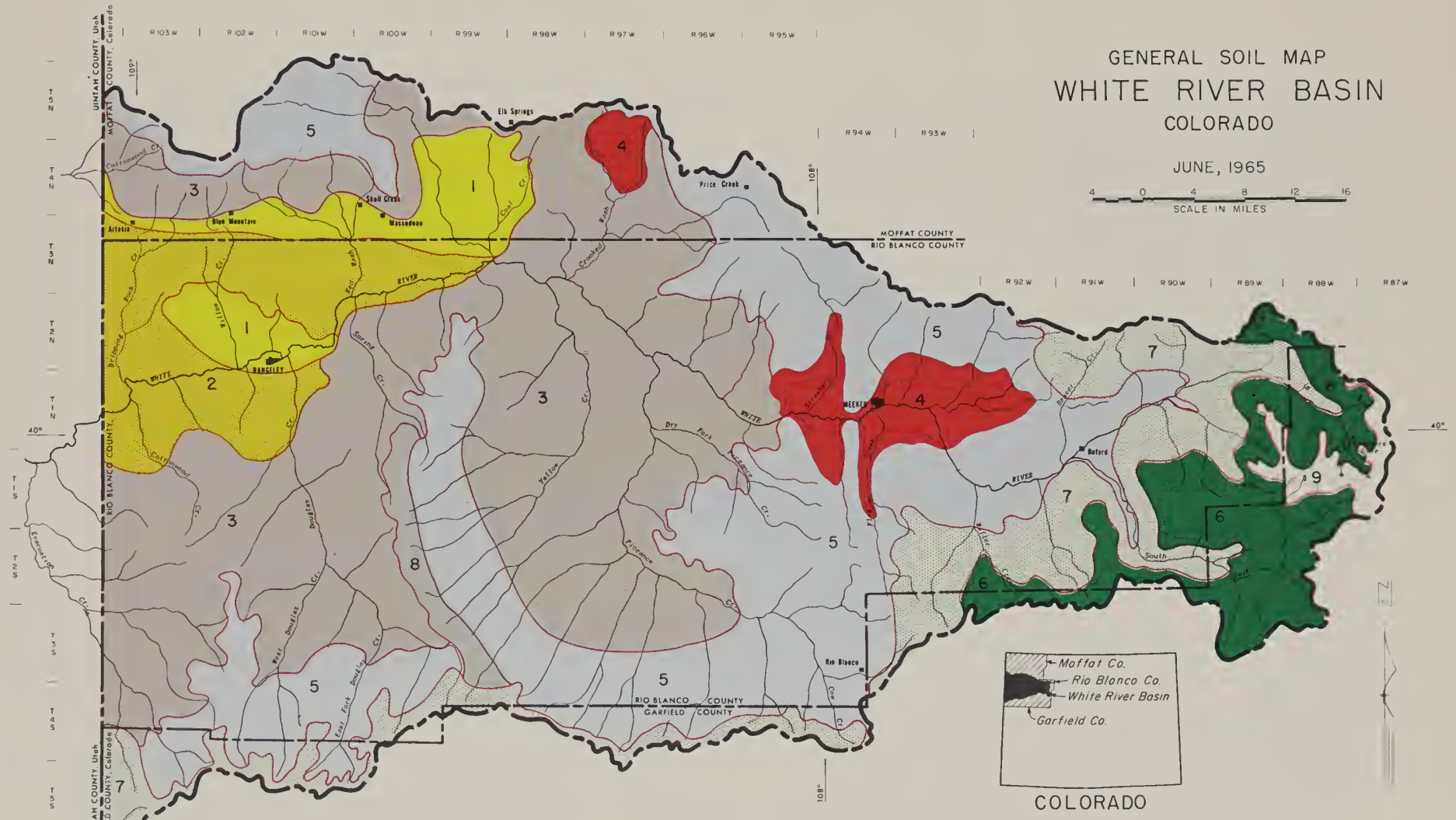
[3] Soil Survey Staff, SCS, USDA "Soil Classification, a Comprehensive System 7th Approximation," 1960 and as amended June 22, 1964.

[4] Aandahl, Andrew R. "The First Comprehensive Soil Classification System." Journal of Soil and Water Conservation 20:243-246, 1965.

GENERAL SOIL MAP
WHITE RIVER BASIN
COLORADO

JUNE, 1965

4 0 4 8 12 16
SCALE IN MILES



COLORADO

L E G E N D

MAP SYMBOL	NAME OF MAPPING UNIT
1	Shallow and deep, light colored shale soils of the deserts
2	Shallow, light colored loamy and rocky soils of the deserts
3	Shallow rocky and deep moderately dark colored soils of the uplands
4	Deep, moderately dark colored soils of the mesas and valleys
5	Moderately deep and deep, dark colored soils of the uplands
6	Light colored soils of the cold, forested mountain slopes
7	Dark colored soils of the cold, forested mountain slopes
8	Shallow, dark colored soils of mountain cliffs and ridges
9	Shallow, and deep, dark colored soils of the alpine region

U. S. DEPARTMENT OF AGRICULTURE. SOIL CONSERVATION SERVICE M-4457

The Basin is divided on the general soil map among 9 units that have been delineated as described above. Separations between units are generalized in accordance with requirements imposed by the map scale. Acreage distribution of units and percent each occupies is given in table 3. Soil mapping units delineated on the general soil map are described on the following pages.

Table 3.--Acreage of Soil Mapping Units and percent of area covered, White River Basin in Colorado.

Map symbol	Acres	Percent
1	118,000	4.8
2	185,000	7.6
3	839,000	34.4
4	86,000	3.5
5	741,000	30.4
6	160,000	6.6
7	256,000	10.5
8	28,000	1.2
9	24,000	1.0
Total	2,437,000	100.0

Source: USDA Field Party

Soil Mapping Unit 1: Shallow and deep, light colored shale soils of the deserts.

Soils of this unit are located in two areas on the general soil map. One is the desert basin near Rangely and the other extends from near Elk Springs westerly to the Utah State line. These have a total area of 118,000 acres or a little less than 5 percent of the Basin.

The landscape is characterized by rolling shale hills broken by narrow, gently sloping strips of alluvial soils bordering drainageways and colluvial slopes. Slope gradients are chiefly in the 5 to 25 percent range but there are portions with less than 5 percent. Larger areas where slopes are from 0 to 5 percent are along waterways or on bottomlands and terraces bordering the White River and its tributaries. Very steep shale badlands and escarpments border the boundaries of this mapping unit at many places and are particularly noticeable north and west of Rangely.

Desert rangeland
(Soil Mapping Unit 1)

Soils of unit 1 have formed under a low effective annual precipitation that varies from 8 to 12 inches. Elevations range from 5,200 to 6,200 feet. The mean annual temperature is about 47° F. and the frost-free period at Rangely, which is considered representative, is 124 days.

Soil parent materials are mainly calcareous, clayey shales and sandstones. However, sandy and gravelly outwash, wind-blown sands and silts, and alluvial sediments are also extensive.

The soils are chiefly shallow over sandstone or shale, but deep soils have formed in alluvial and wind-blown deposits that extend over bottomlands, terraces and mesas.

Surface soils are light colored and range in texture from sandy loam to silty clay. Subsoils are principally clay loam, silty clay loam, or clay in texture and have a moderate to slow permeability rate. Sandy subsoils with a rapid permeability rate are a minor component within the unit. Generally, these soils have an alkaline reaction and are limy at or within a few inches of the surface. Some soils

on fans and terraces are very strongly alkaline in reaction and high in exchangeable sodium as evidenced by scattered "slick spots" that are devoid of vegetation. Injurious accumulations of soluble salt are largely restricted to bottomland soils and areas bordering shale badlands.

The composition of this map unit by Great Soil Groups except for Regosols that are included within Desert and Sierozem soils, is estimated as follows:

Percent	1949 Great Soil Group	1965 Great Group, Subgroup or Family
55	Lithosols (Shale 45%) (Sandstone 10%)	Haplorthents (Thin 45%) (Lithic 10%)
28	Desert & Sierozem soils	Haplargids and Camborthids
7	Alluvial soils	Haplorthents
5	Solonetz soils	Natrargids
5	Land types (Shale badlands 5%)	Land types (Shale badlands 5%)

The largest component of mapping unit 1 is shallow residual clay shale soils on hills and ridges. Deeper soils occupy narrow gullied drainageways and alluvial fans. They are forming in recent accumulations of sediment washed from higher shale and sandstone hills. The deeper soils on smoother slopes are productive at locations where irrigation water is available. Deep soils are in many of the narrow valleys between Artesia and Elk Springs. There are scattered tracts of irrigable land but many individual areas are divided by deep channels and gullies.

Erosion in the rolling shale hills and shale badlands is spectacular but is mainly geologic in nature. Deep and extensive gullying along drainageways and narrow valleys is of much greater agricultural significance. At many places dissection by gullies severely limits use of the land. Bridging of gullies increases the cost of highway construction.

Soil Mapping Unit 2: Shallow, light colored loamy and rocky soils of the deserts.

There is only one delineation of this unit on the map. It is mainly confined to northwestern Rio Blanco County and very nearly surrounds that segment of unit 1 adjacent to Rangely. It comprises 185,000 acres or about 8 percent of the Basin.

The unit encompasses steep slopes, canyons, and rocky ledges bordering the White River and tributary intermittent streams. The deeply cut, narrow drainageways are separated at frequent intervals by higher lying uplands and mesas. Shale outcrops and badlands occupy many lower slopes. Slope gradients are generally 10 to 70 percent but gradients of less than 5 percent are common on alluvial fans, bottomlands and mesas.

Most of unit 2 is at an elevation of between 5,200 and 6,200 feet. Climate in this unit is somewhat similar to that at Rangely with a mean annual precipitation estimated at 8 to 12 inches. Mean annual temperature is about 47° F. and the frost-free period is from 90 to 124 days.

Soil parent materials are primarily sandstones and shales or reworked material from residual beds. Gravelly, calcareous outwash, and local eolian deposits cap mesas and some upland ridges. Soils forming in recent alluvium are of minor extent.

Surface soils are light colored, thin and usually calcareous. Unit 2 has more stony surface soils and associated rock outcrop than are present in unit 1. Conspicuous rock ledges along Raven Ridge northwest of Rangely, are representative. Surface textures of soils forming from sandstone are usually stony or gravelly sandy loams while clay and clay loam textures are common for shale derived soils. Subsoils range from sandy loam to clay in texture. Over most of the area, underlying sandstone or shale beds are within 20 inches of the surface and plant rooting depths are restricted.

Composition of unit 2 by Great Soil Groups, except for Regosols that are included with the zonal soils and land types, is estimated as follows:

Percent	1949 Great Soil Group	1965 Great Group, Subgroup or Family
60	Lithosols (Sandstone 30%) (Shale 30%)	Haplorthents (Lithic 30%) (Thin 30%)
25	Desert and Sierozem soils	Haplargids and Camborthids
5	Alluvial soils	Haplorthents
10	Land types (Rock outcrop 5%) (Shale badlands 5%)	Land types (Rock outcrop 5%) (Shale badlands 5%)

Geologic erosion is conspicuous along rocky canyons and shale slopes. Severe accelerated water erosion is principally confined to stream bank cutting and deep gullying in narrow valleys and swales. Portions of this unit are within "Frail Watershed Lands" [1] that have been described and inventoried by the Bureau of Land Management.

Soil Mapping Unit 3: Shallow rocky and deep moderately dark colored soils of the uplands.

This is the largest unit in the Basin. It extends over 839,000 acres or slightly more than 34 percent of the Basin. Much of it covers a broad belt lying between the deserts and unit 5. Major creeks are: Evacuation, Cottonwood, Douglas, Spring, Yellow and Piceance.

Spring grazing
(Soil Mapping Unit 3)

The landscape is highly dissected by creeks and their intermittent tributaries. There is a repeating pattern of narrow alluvial valleys along creeks flanked by canyons or very steep rocky slopes which rise to higher lying uplands. Narrow bands of rolling upland or mesas form divides between upper reaches of creek tributaries.

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[1] Jensen, Cyril L. "A Preliminary Study and Report on Frail Watershed Lands". U. S. Department of the Interior, 1964.

Slope gradients usually range between 10 and 60 percent over most of the unit. Those of less than 10 percent are confined to alluvial valleys, mesas and upland divides.

Elevations within this unit are, for the most part, between 6,000 and 7,000 feet. Climate here is more favorable for plant growth than in the deserts of units 1 and 2. Annual precipitation is 12 to 15 inches and mean annual temperature is a little less than 47° F. The frost-free period is about 100 days.

Soil parent materials are mainly limy sandstones and shales along with reworked valley fill derived from sandstone and shale. Much of the fill material is stony or gravelly. Eolian deposits mantle portions of the rolling upland divides between creeks. Recent alluvium is of minor extent. Alluvial valleys have been markedly influenced at many places by sediments and colluvium from nearby slopes.

Composition of map unit 3 by Great Soil Groups, except for Regosols included within the Brown soils and land types, is estimated as follows:

Percent	1949 Great Soil Group	1965 Great Group, Subgroup or Family
60	Lithosols	Haplorthents (Lithic and Thin)
25	Brown soils	Haplargids and Camborthids
5	Alluvial soils	Haplorthents
2	Solonetz soils	Natrargids
8	Land types (Rock outcrop 3%) (Rough gullied land 3%) (Shale badlands 2%)	Land types (Rock outcrop 3%) (Rough gullied land 3%) (Shale badlands 2%)

One of the most extensive components of unit 3 is the light colored, shallow, stony soils that are intermingled with large sandstone boulders and rock outcrops. They overlie sandstone or shale at depths of less than 20 inches, and are usually calcareous. Stony soils are extensive near narrow valleys and canyons that dissect the unit. At many locations soft sandstone is penetrated by tree roots. Closely associated with rocky soils are deeper soils with weak horizonation that have high proportions of coarse fragments in the subsoil. Deeper soils are in footslope positions below and within the complex patterns of shallow soils.

Medium depth soils occupy lower portions of many narrow mesa divides. They have formed in local wind deposited sandy materials derived for the most part from sandstone. Deep, moderately dark colored loamy soils which are noncalcareous to depths of 6 to 24 inches occupy smoother slopes on the divides. Often they have formed in calcareous wind-blown deposits of loamy texture.

Accelerated erosion is chiefly confined to rolling upland divides and stream valleys. Water erosion on rocky, gravelly pinyon-juniper slopes is principally along roads and hunting trails. Trails and roads along steep upper slopes have had a striking effect in concentrating runoff water. Deep gullying and destructive bank cutting is visible along all intermittent creeks and head cutting is common on side drains. Summer storms frequently wash out many bridges and creek crossings within this unit. Detrimental flood deposits are left on alluvial fans and bottomlands which formerly supported good stands of grass.

Soil Mapping Unit 4: Deep moderately dark colored soils of the mesas and valleys.

Unit 4 consists of 86,000 acres and comprises about 3.5 percent of the Basin. There are two areas of this unit as shown on the general soil map. The most extensive embraces the valleys and mesas located west and east of Meeker. A smaller one is located in Moffat county near the north edge of the Basin and above Crooked Wash.

The landscape near Meeker consists of gently sloping bottomlands and terraces that are bordered by higher benches or mesas. Mesas and benches merge at their upper margins with steeper slopes of unit 5 on the map. The smaller delineation in Moffat County has much less bottomland and terrace land, since it is far from the river valley. Gently sloping terraces and mesas are separated at successive levels by scarp faces or steep upland slopes. The smoother bottomlands and terraces have gradients of less than 5 percent. Gradients on mesas and bordering uplands are between 5 and 15 percent. Steep slopes on scarps and those along larger drainageways dissecting the mesas range from 15 to 60 percent.

Soil unit 4 has an elevation range of 6,000 to 7,000 feet; however, it is mostly at an elevation of 6,100 to 6,600 feet. Climatic data for Meeker shows a mean annual precipitation of about 17 inches, a frost-free period of 94 days, and a mean annual temperature of 44° F. Weather at Meeker is more favorable for crop production than at the eastern margins of the unit, due to the longer frost-free season.

Irrigated hay meadow
(Soil Mapping Unit 4)

Parent materials for soils of unit 4 are represented by a wide variety of materials. Bottomland and stream terrace soils have formed in mixed alluvial deposits. Large areas of wind blown loamy and silty materials, along with gravelly and cobbly outwash, exist within the unit delineations. They are more widespread here than in the other 8 units shown on the general soil map. At many places loamy and gravelly materials mantle residual clayey shales to depths of 4 to 10 feet. Shales where not covered have also furnished residual and reworked parent materials.

Surface soil layers are brown or grayish brown and have a moderate organic matter content that ranges from 1 to 3 percent. Textures range from sandy loam to clay loam.

Subsoils are permeable and usually more clayey than surface layers. Sandy clay loams, silty clay loams and clay loams are most extensive.

Upland soils are calcareous at depths of 15 to 30 inches and have weak to moderate horizons of lime accumulation.

The following approximate composition of the unit by Great Soil Groups is estimated. Estimates were not made for Regosols as they are included within the zonal soils.

Percent	1949 Great Soil Group	1965 Great Group, Subgroup or Family
45	Chestnut soils	Argiustolls and Haplustolls
40	Brown soils	Haplargids and Haplorthents
10	Alluvial soils	Haplorthents, Haplustolls, and Haplaquolls
5	Lithosols	Haplorthents (Lithic and Thin) Haplustolls (Lithic)

The dominant soils are deep. Soils near edges of mesas and bordering scarps and drainageways are often underlaid at depths of 20 to 60 inches by clay shales, sandstones, or cobble and gravel mixtures.

Erosion is extensive in the area around Meeker. About 40 percent of that delineation is under cultivation. Water erosion is a problem on sloping fields whether dry farmed or irrigated. There is some gullying along drainageways and deep cutting in irrigation ditches.

Soil Mapping Unit 5: Moderately deep and deep, dark colored soils of the uplands.

Soils of unit 5 occupy approximately 741,000 acres or over 30 percent of the Basin. This unit is second only to unit 3 in extent. For the most part it lies above unit 3 and below unit 7. The upper reaches of the main tributaries of the White River extend across the unit boundaries.

The landscape consists of steep lower mountain slopes of rugged relief dissected by narrow valleys and streams. The sharp ridges of the Grand Hogback are representative of portions of this unit. Steep slopes with gradients between 10 and 60 percent are most common. Gradients of less than 10 percent are generally limited to colluvial slopes, swales, fans and alluvial bottomlands.

Most of the unit is at elevations between 7,000 and 8,000 feet but there are extremes from 6,400 to 8,800 feet. Soil moisture conditions are more favorable for plant growth due to higher precipitation and lower evaporation associated with higher elevations. Data from the Marvine station show a mean annual precipitation of about 20 inches, a mean annual temperature of nearly 40° F., and a frost-free period of 47 days. Since unit 5 extends west to the State line, a range of from 15 to 20 inches in annual precipitation and 45 to 100 days in length of frost-free period can be expected.

Parent materials consist of mixed alluvium, colluvium, and outwash deposits along streams and valleys. Gravelly and stony valley fill is extensive along the lower mountain slopes. Parent rocks are chiefly sandstones, quartzites, shales and basalt. They have furnished the source for much reworked material in which soils have formed.

The approximate composition of the unit by Great Soil Groups is shown below. Estimates were not made for Regosols as they are included within the zonal soils:

Percent	1949 Great Soil Group	1965 Great Group, Subgroup or Family
45	Chernozem soils	Argiudolls and Argiborolls Hapludolls and Haploborolls
35	Chestnut soils	Argiustolls and Haplustolls
15	Lithosols	Haplustolls and Hapludolls (Lithic)
3	Alluvial soils	Haplustolls and Haplaquolls
2	Land types (Rock outcrop)	Land types (Rock outcrop)

Dominant soils of this unit have dark gray or dark grayish brown surface layers that are high in organic matter content. Surface layers are loamy with loam and sandy loam textures being most common. On steep colluvial slopes coarse fragments from higher lying rock ledges and outcrops are usually scattered over the surface soil. Subsoils are more clayey and may be sandy clay loam to clay in texture. Many subsoils contain gravel, stone, and rock fragments. Lime is usually leached to depths of 40 to 60 inches.

Moderately deep and deep soils are intermingled within this unit. At depths between 20 and 40 inches there is usually sandstone, shale or basalt under moderately deep soils. Deep soils have formed in valley fill and may have dark colored buried soils within the upper

four feet of the profile. Some dark surface soils are unusually thick and extend to depths of 20 to 30 inches.

Erosion is slight to moderate. Most evident is that in cultivated fields where runoff water has concentrated and resulted in rilling and gullying. Under native cover, erosion has been limited to washing along stock trails and minor gullying along drainageways.

Soil Mapping Unit 6: Light colored soils of the cold forested mountain slopes.

Soils of this unit occupy 160,000 acres or about 6.6 percent of the total acreage of the Basin. The unit forms a single irregular band at the upper end of the Basin just below the alpine region. It extends from the headwaters of Miller Creek near the south margin of the Basin, around to Pagoda Peak. All of it is within national forest.

Unit 6 extends over steep, timbered, upper mountain slopes and encompasses many open grassland parks. The landscape is composed of rugged steep mountain slopes broken by headwaters of perennial streams. Higher divides between streams are interspersed with rolling, open areas. Slope gradients are generally between 25 to 75 percent except for divides and parks where gradients of 5 to 25 percent are usual. Slopes less than 5 percent are chiefly limited to alluvial valleys and swales.

Timber land
(Soil Mapping Unit 6)

Elevations are mainly between 9,000 and 10,000 feet although there is a spread of from 8,000 to 11,000 feet for low and high points. The mean annual precipitation is high and exceeds 20 inches while mean annual temperature is low, probably less than 35° F. The frost-free period is so short that cropping is not practical except for grasses and hay.

Parent materials are principally residuum and reworked materials from granite, sandstone, shale and basalt. Glacial deposits are frequently above the larger streams. Colluvial and alluvial deposits are common along lower slopes and drainageways.

The most extensive components of the unit consist of acid forest soils which either have no A_1 or very thin A_1 horizons. The underlying conspicuous light colored or ashy A_2 horizons are moderately thick and tongue into blocky subsoils.

Surface soil layers are loamy. Subsoils range from sandy loam to clay in texture and often are gravelly or stony. Subsoils are permeable and generally deep.

Composition of this map unit according to Great Soil Groups is estimated as follows, except for Regosols included within Chernozem and Gray Wooded soils:

Percent	1949 Great Soil Group	1965 Great Group, Subgroup or Family
60	Gray Wooded soils	Eutroboralfs and Glossoboralfs
15	Lithosols	Haploborolls (Lithic)
10	Chernozem - Gray Wooded Intergrade soils	Boralfic Argiudolls Boralfic Argiborolls
10	Chernozem	Argiborolls and Argiudolls
3	Alluvial soils	Hapaquolls and Cryaquolls
2	Land types (Rock outcrop)	Land types (Rock outcrop)

Accelerated erosion is chiefly limited to areas along roads and trails where runoff water concentrates.

Soil Mapping Unit 7: Dark colored soils of the cold, forested mountain slopes.

This unit covers 256,000 acres or more than 10 percent of the Basin. It is contained within two delineations on the map. One extends as a narrow strip bordering the Basin's south boundary from the Utah State line easterly nearly to the main highway south of Rio Blanco. The other extends east from Rio Blanco as a broader belt around the upper part of the Basin.

The landscape consists of ridges, steep lower mountain slopes and valleys. Springs and perennial streams are common except along the headwaters of Douglas and Piceance Creeks.

Excellent timber and grazing land
(Soil Mapping Unit 7)

Slope gradients usually range from 10 to 50 percent. Slopes of less than 10 percent occupy divides, open parks, and alluvial valleys.

Most of unit 7 is at elevations between 8,000 and 9,000 feet although at the upper end of the Basin elevations between 9,000 and 9,500 feet are included.

Moisture conditions within this unit are favorable for plant growth as mean annual precipitation ranges from 20 to 25 inches. The drier part of the unit is along the south boundary of the Basin west of Rio Blanco. The growing season is short with a period of less than 50 frost-free days. The mean annual temperature is less than 40° F.

Parent rocks are principally sandstone, shale, quartzite and basalt. Glacial and local wind reworked deposits are also extensive. On lower slopes and narrow valleys colluvial and alluvial deposits are the chief parent materials.

The approximate composition of this unit by Great Soil Groups except for Regosols that are included within the zonal soils is estimated as follows:

Percent	1949 Great Soil Group	1965 Great Group, Subgroup or Family
60	Chernozem - Gray Wooded Intergrade	Mollic Glossoboralfs Mollic Eutroboralfs Boralfic Argiudolls Boralfic Argiborolls
15	Gray Wooded soils	Eutroboralfs and Glossoboralfs
15	Lithosols	Haploborolls (Lithic)
5	Chernozem soils	Argiborolls and Argiudolls
3	Alluvial soils	Haplaquolls and Cryaquolls
2	Land types (Rock outcrop)	Land types (Rock outcrop)

The major component of this map unit consists of soils that have moderately thick, dark colored, granular A_1 horizons underlaid by light colored A_2 horizons. The light colored A_2 horizons tongue into blocky, more clayey, subsoils.

The gray or grayish brown to dark gray or dark grayish brown surface layers are high in organic matter content. They are neutral in reaction and have a loamy texture. Loam and sandy loam are the predominant textural classes and gravel or stones are often present.

Subsoils are more clayey than surface layers and have a blocky structure. Sandy clay loam and clay loam textural classes are common. Subsoils are thick and moderately to slowly permeable.

Underlying parent materials are permeable and often calcareous. Depth to underlying bedrock is variable but is usually more than four feet.

There is little accelerated erosion within unit 7 except along stock trails and roads where runoff water concentrates.

Soil Mapping Unit 8: Shallow dark colored soils of mountain cliffs and ridges.

This soil unit is the second smallest shown on the map. With only a single delineation of 28,000 acres, it comprises slightly more than 1 percent of the Basin. This unit extends as a narrow band above Spring Creek across the west side of Cathedral Bluffs and southeast nearly to the Garfield county line. Large oil shale sequence sections in the Green River formation are exposed along the west face of Cathedral Bluffs (photograph page 8).

Conspicuous features of the landscape are light colored cliffs and escarpments. The white, light gray to very pale brown exposed shale, marl, sandstone and limestone beds extend along an irregular, jagged strip seldom more than a mile or two wide. Above the cliffs are sharp rolling windswept ridge crests which form a divide between the Douglas Creek and Piceance Creek drainage basins, while below are very steep talus slopes. Included in the landscape are highly dissected uplands forming headwaters of intermittent drains that flow west and north into Douglas Creek.

Slopes are irregular and broken. They usually extend for only short distances before changing in aspect. Slope gradients on rolling ridge crests above the cliffs are 5 to 25 percent. Between and below vertical cliff faces slopes range from 25 to 75 percent.

Most of unit 8 is at an elevation between 8,000 and 8,500 feet but extreme limits are 7,000 to 8,700. Mean annual precipitation is 16 to 20 inches. The frost-free period and mean annual temperature is similar to that of unit 7. A striking difference characterizing unit 8 is that much of the annual precipitation is lost by evaporation and runoff on bare exposures and windswept ridges. Consequently, a smaller portion of total precipitation is available for plant growth than within unit 7.

Soil parent materials have been mainly calcareous shales and fine grained sandstones. Marly deposits and limestone beds are also common. There has been much local reworking of materials from residual beds. Many of the colluvial slopes contain high proportions of channery and stone.

Composition of unit 8 by Great Soil Groups is estimated below:

Percent	1949 Great Soil Group	1965 Great Group, Subgroup or Family
65	Lithosols	Lithic Haploborolls Lithic Haplustolls Lithic Haplorthents
25	Regosols	Haploborolls Haplustolls
10	Land Types (Rock outcrop)	Land Types (Rock outcrop)

Soils of this unit are predominantly shallow. Usually underlying shales or fine grained sandstones are at depths of 6 to 20 inches. Soil depth changes frequently within short distances. Deeper soils with underlying parent beds at depths of 20 to 40 inches occupy about 25 percent of the unit. Plant roots enter most of the residual beds and most shales can be readily penetrated with digging tools.

On west and south facing slopes surface soils are lighter colored and limy. Shaly loams and channery sandy loams are the common surface soil textures on steep upper slopes. Deep soils containing high proportions of shale and stone occupy some lower colluvial slopes.

Erosion within this unit is mainly geologic in character. Parent rocks, steep slopes and strong winds slow the rate of soil formation. In addition, much weathered material moves down slope as colluvium. Accelerated erosion is principally by wind on ridge crests where overgrazing had denuded shallow loamy soils. Gullying is limited to narrow drainageways occupied by deep, friable soils.

Soil Mapping Unit 9: Shallow, and deep, dark colored soils of the alpine region.

This is the smallest unit on the general soil map and is represented by a single delineation of 24,000 acres. It is located at the head of the Basin, above Trappers Lake, and constitutes about 1 percent of the Basin.

The alpine region is a steep windswept rocky grassland above timberline with a landscape composed of high rugged mountain peaks with intervening ridges and valleys. Slopes are steep with gradients of 10 to 80 percent being most common. Smoother slopes on ridges are usually 10 to 30 percent while steeper rimlands have gradients up to 100 percent.

Wilderness use
(Soil Mapping Unit 9)

Nearly all of this unit is located at elevations between 11,000 and 12,000 feet. Climate is distinctive for its low temperatures and extremely short growing season.

Seasonal temperature ranges are extreme and there is a large daily range with rapid changes. The mean annual temperature is less than 30° F. Mean annual precipitation is between 25 and 40 inches. Snow accumulations are great during winter but summer moisture as rain is comparatively low.

Parent rocks for alpine soils in the White River Basin are mainly basalt and granite with some sandstone and shale. Many soils have formed in rocky colluvium, and talus slopes are common.

Soil components of the alpine region according to Great Soil Groups are estimated as follows:

Percent	1949 Great Soil Group	1965 Great Group, Subgroup or Family
55	Alpine Turf	Cryorthods and Cryumbrepts
15	Alpine Meadow	Cryaquolls and Cryaquods
5	Alpine Bog	Histosols
10	Lithosols	Lithic Haplorthents
15	Land types (Rock outcrop)	Land types (Rock outcrop)

Soils of this unit can be divided into those that are well drained and those that are poorly drained. Highly organic and peaty soils have formed in many small and large depressions where water accumulates. Bog soils are conspicuous although their total area is not large.

Well drained turf soils occupy most of the landscape where soils have formed. Surface soils are dark colored and high in organic matter. They are moderately sandy to loamy in texture and are usually gravelly or stony. Surface soils are acid in reaction. Subsoils are gravelly or stony sandy loams and loams which are mildly acid in reaction and readily permeable. Underlying gravelly or rocky parent materials are generally at depths of 10 to 30 inches.

Alpine Meadow soils are in association with Alpine Turf and Bog soils and occupy cirque basins and poorly drained areas. Often low growing willows serve to identify areas of Alpine Meadow soils.

Roots are concentrated in surface soil layers, mainly in the upper 5 or 10 inches. Even in well drained soils roots seldom extend below a depth of 20 inches due to low soil temperatures.

WATER RESOURCES

Water Supply

The water supply for the White River Basin comes principally from melting of winter snowpacks on the high mountains, augmented by summer precipitation. There is considerable variation in watershed

yield, reflecting climatological and meteorological differences in various parts of the Basin. Water yields range from more than 20 inches of runoff for some of the higher areas in the Basin, to less than one inch in the desert areas. On an average, 42 percent of the annual discharge occurs in the months of May and June.

Total undepleted water supply [1] above the State line averaged about 525,400 acre-feet annually for the 1943-60 period. This excludes on-site use by native forest and range vegetation. For purposes of estimating water yield and water use, the Basin has been divided into two hydrologic areas, the upper and lower basin. This division is shown on the water resource frontispiece. Nearly 94 percent of the water comes from the upper basin which is 1,034 square miles in size or about 27 percent of the total area.

The estimated average annual discharge of water from the basin at the State line was 487,000 acre-feet for the 1943-60 period. This includes two minor drainages, Cottonwood Creek (tributary to Cliff Creek) and Two Waters Creek. These originate in Colorado and enter the Green River and White River in Utah. Discharge from these two drainages bypass the stream gage on the White River near Watson, Utah, which is located about seven air-miles west of the State line. Average annual discharge at this gage during the 1943-60 period was 487,900 acre-feet, including accretions below the State line.

There are 73 natural lakes within the national forest. In addition, eleven reservoirs have been developed for recreation, fishing and irrigation. Developments on other public lands include about 200 stock water and erosion control structures. Approximately 700 small reservoirs have been constructed on private land for irrigation, stock water, fishing and recreation purposes.

Snow surveys have been conducted within the Basin since 1936. Regular forecasts of prospective water supplies are made monthly during winter and spring, and are distributed to water users, water resource agencies and others having a need for these data. There are two snow courses in the Basin, one on the upper main stem and the other on the South Fork of White River. These two courses have been adequate to meet the requirements of stream flow forecasts.

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[1] Total undepleted water supply is used herein in the sense of the aggregate natural runoff before diminishment by man-related depletions.

Water Quality

This report is concerned only with generalized aspects of water quality in the Basin in relation to its suitability for agricultural and recreational purposes. Several studies are being made by the Bureau of Reclamation, Geological Survey, and Federal Water Pollution Control Administration which will provide detailed information about pollution and public health aspects of water quality in the Basin. No attempt has been made to evaluate these factors in this report.

More than 90 percent of the water supply originates in the upper basin. A major portion of the area upstream from the confluence with Miller Creek, southeast of Meeker, is underlain by rocks of Pennsylvanian and Permian age. Much of this area, especially the higher elevations, is capped with rocks of the Tertiary age. The dissolved solids concentration in the water draining this area usually does not exceed 300 ppm and is principally calcium carbonate. Below this area, the Basin is underlain by sedimentary rocks of Cretaceous and Tertiary age which contain more readily soluble minerals. A higher amount of dissolved solids are carried by the streams draining these areas.

In general, the water of the Basin is of good quality for recreation and irrigation. It has a favorable sodium-calcium ratio and in most areas has relatively low total dissolved salt content during the irrigation season. Late summer and winter flows of some lower Basin tributaries contain high concentrations of dissolved salts.

Table 4 gives approximate amounts of dissolved solids carried by the river at various locations. The figures illustrate the increase in total dissolved solids content in the river from its upper reaches down to the stream gage near Watson, Utah, located 7 air-miles west of the State line.

Above its junction with the South Fork, the White River and its tributaries carry small amounts of both sediment and dissolved salts, while near Meeker and below, there is a marked increase. The increase is due to inflow from saline areas and mineral springs. Meeker Spring, actually an abandoned flowing well, is located 4 miles east of Meeker and discharges approximately 160 tons TDS (Total Dissolved Solids) per day into the White River. Another large contributor is the artesian aquifer underlying the Piceance Creek Basin. This aquifer, bearing warm mineralized water, allows seepage of highly saline water to the surface. Concentrations are highest during late summer and winter flows. They are lowest during the spring snowmelt season due to dilution from increased volumes of surface water.

Table 4.--Concentration and discharge of dissolved solids for streams in the White River Basin. [1]

Stream	Water discharge (thousands of acre-feet per year)	Dissolved solids: Weighted average concentration (ppm)	Dissolved solids: Discharge: Thousands of tons per year	Dissolved solids: Discharge: Tons per square mile of drainage area per year
White River near Buford	240	164	54	211
South Fork White River near Buford	205	144	40	258
White River near Meeker	462	244	153	201
White River near Watson, Utah	554	439	331	82

[1] Data for annual averages for water years 1914-57 adjusted to 1957 conditions.

Source: U. S. Geological Survey

Concentration of dissolved solids varies with stream discharge, salt input, evaporation, and other factors. It is relatively stable and constant under virgin conditions. Natural processes and abandoned oil wells, which have penetrated the mineralized artesian aquifer, are major sources of dissolved solids in the streams under today's level of development. Further development of irrigated lands in the Basin will slightly increase the total dissolved solids. Of major concern is the potential development of an oil shale industry. Proper planning and management will be necessary to restrict stream pollution that could result from industrial wastes.

There have been few studies of sediment loadings within the Basin. The most reliable estimates and long term studies have been made in the upper reaches near Buford. Suspended sediment discharge for this area averages 33,000 tons per year. This is quite low, especially when compared with other drainages in the Green River Basin. The lower White River tributaries contribute much higher loads. Sediment loads fluctuate widely in the course of a year with larger amounts carried by early season snowmelt runoff from intermediate and lower elevation watersheds. Summer cloudburst storms on lower tributaries deposit large quantities of sediment near their confluence with the main stream. These often remain in the channel until transported downstream by high water of the next snowmelt season.

Water Rights [1]

Appropriation of water in the State of Colorado is authorized by the State Constitution and by certain statutes adopted pursuant to the Constitution. Unappropriated water of any natural stream of the state is subject to appropriation for beneficial use under the doctrine of the first in time is first in right to the continued use of the water.

The procedure for acquiring a water right is for the prospective appropriator to commence surveys for or construction of necessary water use facilities as the first step in establishing an appropriation. Thereafter the appropriator should file a statement of a claim in the office of the State Engineer for the use of water. An appropriation is completed when the water is applied to a beneficial use. The appropriator may then have the water right established by an adjudication proceeding in the proper District Court. The District Court then enters a decree for the water right.

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[1] This statement was prepared by the Colorado Water Conservation Board for inclusion in this report.

The State Engineer has administrative control of the public waters of the state. It is his duty, along with his duly authorized representatives, to administer the distribution of water in accordance with decrees. He also has the duty to see that waters of the state are preserved for the use and benefit of the citizens and inhabitants of the state, and are not wasted.

The White River originates entirely within the State of Colorado. During the flood period of the year, which occurs in the spring, the White River and its tributaries carry quantities of unappropriated water. There exists, therefore, an excellent opportunity to establish new water rights by constructing more reservoir storage facilities on the White River and its tributaries to capture unappropriated water and place it to beneficial use. Beneficial use may be affected by release and diversion of stored water or by exchange for direct flow diversions upstream.

LAND AND WATER USE

Land Use

Almost the entire Basin is used for agricultural production. Primary land uses are grazing or a combination of timber and grazing, timber production, irrigated or dryland crop production, and recreation. Frontispiece 2 provides a graphic illustration of the generalized land use in the Basin, and the Land Use Map (following page 36) shows the general pattern of land use. Table 5 shows estimated land use by ownership. Land uses are generalized and these lands may have several other uses.

The irrigated cropland (35,200 acres) together with the dry farmland (34,000 acres) occupies less than 3 percent of the land area of the Basin. Most of the irrigated cropland is used to produce forage for livestock, while wheat is the most important dryland crop. Climatic factors limit crop production at higher elevations to mostly grass or legume-grass hay and irrigated pasture. At lower elevations the growing season is long enough for production of alfalfa hay and small acreages of corn.

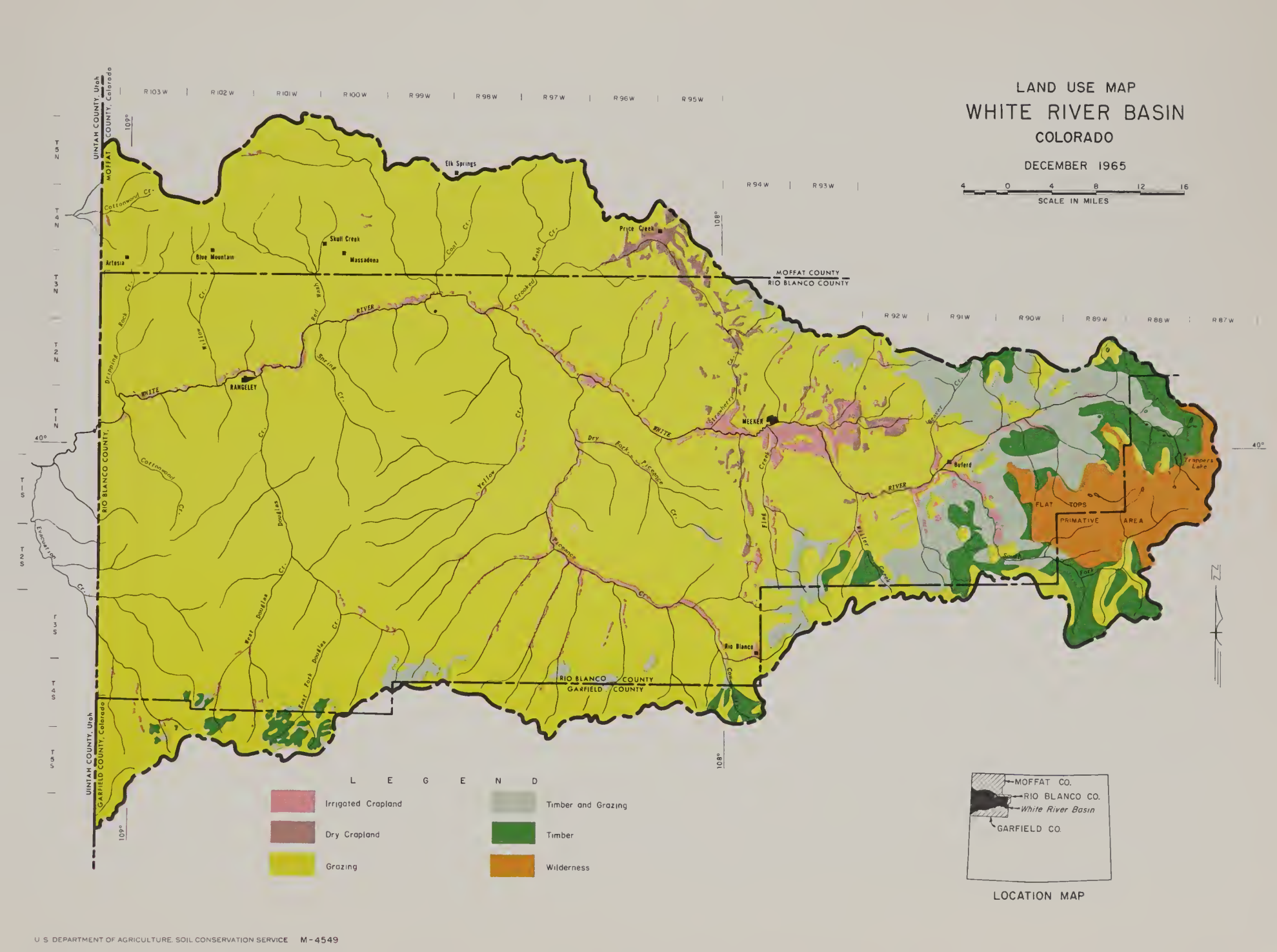
Approximately 87 percent of the land is used for grazing by domestic livestock and wildlife. Included in the timber and grazing lands are timber areas with predominantly aspen cover or open commercial timber

Table 5.--Land use by ownership, White River Basin in Colorado, 1964

Ownership	Cropland [1]		Grazing	Timber & grazing	Timber	Wilderness	Recreation	Other [2]	Total
	Irrigated	Dry farm							
	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Private land	33,000	34,100	356,400	28,500	3,500	0	2,000	42,600	500,100
State lands									
State & local government	0	0	20,500	0	0	0	0	600	21,100
Game, Fish & Parks Commission	2,200	0	19,000	1,600	0	0	800	13,900	37,500
Federal lands									
Bureau of Land Management	0	0	1,416,100	59,900	7,400	0	4,300	36,200	1,523,900 [3]
Forest Service	0	0	68,300	91,000	100,000	82,000 [4]	100 [5]	13,000	354,400 [3]
Total	35,200	34,100	1,880,300	181,000	110,900	82,000 [4]	7,200	106,300	2,437,000
Percent	1.4	1.4	77.1	7.4	4.6	3.4	.3	4.4	100.0

[1] 1943-60 average.
[2] Includes water acres, town sites, rights-of-way, mineral lands, and other miscellaneous uses.
[3] Bureau of Reclamation and other withdrawal lands included.
[4] Grazing is permitted on 45,500 acres of the Flat Tops Primitive Area.
[5] Includes only developed or designated recreation sites.

Source: USDA Field Party from data furnished by the Soil Conservation Service, Forest Service, Bureau of Land Management, and the State of Colorado.



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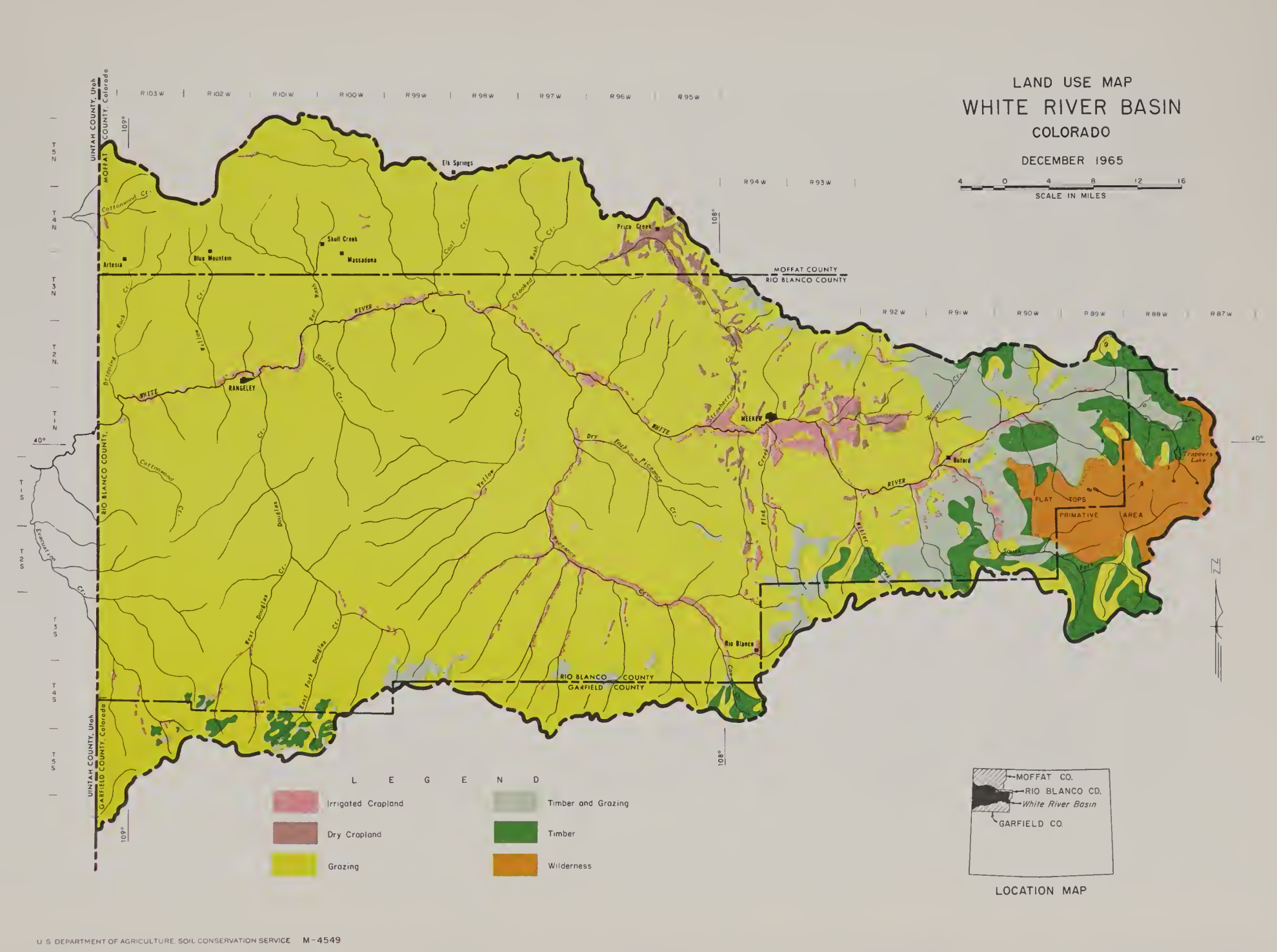

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areas which provide good grazing. These lands are also important as watershed lands, wildlife habitat, and for recreational uses such as hunting, fishing, camping and sightseeing.

Commercial timberland occupies 6 percent (147,400 acres) of the Basin. However, as a result of the loss in Englemann spruce stands killed by spruce beetles (64,100 acres), the existing area from which commercial timber could be sold is estimated at about 20,000 acres. It will be many years before there will be substantial commercial timber harvested in this Basin.

The 82,000 acres devoted to wilderness use are located in the headwaters of the Basin within the Flat Tops Primitive Area. These lands are administered to enhance the "wilderness" resource. The wilderness resource includes public recreation, scenic, scientific, educational, conservation, and historical uses and for other purposes for which it may have been established [1], in such a manner as to preserve and protect the wilderness character.

The White River Basin is famous for its mountain scenery and almost all of the Basin provides some form of recreation use. The 7,200 acres of recreation lands are the designated recreation areas or lands occupied by man-made sites and developments for recreation. Included are 2,000 acres of private recreational lands used mostly for mountain home sites, guest ranch facilities, fishing ponds, etc.

The Colorado Game, Fish and Parks Commission owns a total of 37,500 acres of land in the Basin. However, only about 800 acres are used solely for recreation. These include Rio Blanco Lake, Big Beaver Lake (Lake Avery), Meeker Pasturage, and access road rights-of-way. The balance is used for grazing, irrigated cropland, oil shale lands and headquarters or fish rearing units.

Recreation lands under the jurisdiction of the Bureau of Land Management (4,300 acres) include all designated or planned recreation areas. These are not highly developed and consist mostly of streams, natural recreation sites, hunter camps, or historic sites. The 100 acres of national forest shown as recreational lands comprise only developed campgrounds and picnic sites. Under multiple use management almost the entire area of national forest and Bureau of Land Management lands is available and used for some form of recreation activity.

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[1] The grazing of livestock, where established prior to September 3, 1964, shall be permitted to continue subject to wilderness regulations. Pub. Law 88-577.

Colorado Game, Fish and Parks Department
fish rearing units

Lands administered by the Forest Service and the Bureau of Land Management are managed under principles of multiple use to produce a sustained yield of products and services as authorized and directed by the Multiple Use Acts of June 12, 1960 and September 19, 1964, respectively. The multiple use principle provides for management of the resources of these public lands so they are utilized in the combination that will best meet the needs of the American people. The Acts provide for "harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output."

Public lands furnish about 75 percent of rangeland grazing for domestic livestock, most of the range and habitat for big game and wildlife, and most of the outdoor recreation opportunities. They also include the high-elevation areas that are the primary sources of water.

Cover Conditions and Management

Ranch operations within the Basin are predominantly cattle and sheep enterprises. Most ranches have grazing permits on public lands away from their ranch headquarters. The irrigated land produces winter feed for more local livestock than there is rangeland to supply spring, summer and fall grazing. Public range is regulated as to numbers and season of use. Irrigated meadows, seeped pasture land and river bottomlands are heavily grazed to provide forage when animals are off Federal range. Generally they do not provide sufficient grazing capacity, as evidenced by the heavy usage on private rangeland.

The Land Use Map following page 36 indicates the general location of land use in relation to the soil mapping units shown on the map following page 12. Estimated land use by soil mapping units is shown in table 6.

Irrigated Cropland

Irrigated cropland is located in soil mapping units 1, 2, 3, 4, and 5. The most important area of irrigated land, containing the largest block and the greatest volume of production, is in that part of mapping unit 4 adjacent to the town of Meeker. These lands are composed of many old natural meadows on alluvial flood plains and seeped areas, as well as adjacent mesas and slopes. Most are irrigated from canals that divert water from the White River. Irrigated lands in other mapping units are located on scattered alluvial flood plains and terraces along the main river and tributary creeks. Some of the meadows in bottoms of tributary streams particularly in the Piceance Creek area have been taken out of irrigation. These were natural meadows that had been destroyed by gullies caused by excessive runoff resulting from depleted cover in the watershed. Irrigated cropland is used to produce feed for livestock enterprises, with about sixty percent of all crop acreages devoted to production of hay of various kinds. About thirty percent is used for cropland pasture and permanent pasture.

Much of the irrigated land especially on the smaller tributaries and below Meeker, is short of late season water. Many management problems result from seasonal water shortages. Over-irrigation when water is plentiful results in seep spots and salt accumulation. Land development such as land leveling, proper spacing of irrigation laterals, and other water management aids are progressing slowly because of water shortages and low crop yields.

Sediment yield is high from erosion of the irrigated area, particularly along Piceance Creek. Much of the irrigated land on tributaries to Piceance Creek has been gullied and abandoned. The soil material from gullied areas is discharged as sediment to Piceance Creek and the main

Table 6.--Land use estimates by soil mapping units, White River Basin in Colorado, 1964

Land use	1	2	3	4	5	6	7	8	9	Total
	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Cropland [1]										
Irrigated	600	1,300	6,200	20,600	6,500					35,200
Dryland				13,600	20,500					34,100
Grazing	112,400	175,700	795,800	44,600	678,900	10,500	48,400	14,000		1,880,300
Timber and grazing						14,400	166,600			181,000
Timber					14,800	70,500	25,600			110,900
Wilderness						55,600	2,400		24,000	82,000 [2]
Recreation			1,000	200	3,000	1,000	2,000			7,200
Other [3]	5,000	8,000	36,000	7,000	17,300	8,000	11,000	14,000		106,300
Total	118,000	185,000	839,000	86,000	741,000	160,000	256,000	28,000	24,000	2,437,000

[1] 1943-60 average.
[2] Grazing is permitted on 45,500 acres of the Flat Tops Primitive Area.
[3] Includes water acres, town sites, rights-of-way, mineral lands, and other miscellaneous uses.

Source: USDA Field Party

stem of the White River. Irrigation water return flow from steeper lands adds sediment. The sediment content of the upper White River is generally quite low. Below the confluence of Piceance Creek it increases rapidly with additional sediment from drainages through the desert area such as Douglas Creek, Wolf Creek, Red Wash, Willow Creek, Dripping Rock Creek, and others. Many of these creeks have irrigated land along the bottoms.

Dry Cropland

Dry cropland is located in soil mapping units 4 and 5. The predominant cultivated use is production of winter wheat by the summer fallow method. Some of the dry cropland is used for hay and about one half is in planted pasture. Dry cropland in soil mapping unit 4 has moderate precipitation and produces well, but dry cropland in unit 5 is more marginal and much is planted to either temporary or permanent pasture. Some dry cropland on flatter slopes, where moisutre relationships are more favorable, is maintained in hay crops. Winter wheat is planted on the higher steeper lands where summer fallow will store moisture in the subsoil.

Water erosion, both sheet and gully, is quite prevalent on the wheat and fallow lands. These lands are steep and have less cover protection than hay or pasture lands. Soil moves to waterways by snowmelt runoff and summer thundershowers. Eventually this material gets to main streams and is carried as sediment. One of the most needed erosion control practices is to convert the land to close growing plants. Those areas maintained in grain cultivation should be farmed with a system of stubble mulch on fallow, cross slope cultivation and fall chiseling. Planting alternate strips of grass-legume hay in rotation with wheat and fallow is a very effective way of reducing erosion on dry cropland. Grassed waterways are also needed to control gully erosion.

Rangeland

Non-cropland is land in natural vegetative cover and is usually referred to as range or timberland. "Sites" are used as a means of describing natural land cover. "Sites" may be defined as "being a distinct type of land that has a certain potential for producing range forage and timber." The inherent productive capacity, like that of any other agricultural land, depends upon the combined effect or interaction of soil and climate peculiar to the site. The ultimate expression of its particular combination of environmental conditions is the characteristic natural plant community that occurs on the site.

Furthermore, the site retains its capacity to reproduce this plant community so long as the environment and soil condition remains unchanged. Accordingly, a site is not only a product of environment, but it is also a specific area of land that can be recognized and described. Sites are subject to many disturbances that modify or temporarily destroy the vegetation but do not preclude the reestablishment of the ultimate plant community.

Along with site names and location, a range condition is indicated. Range condition indicates productivity of forage species that are components of the vegetative cover. Native forage species usually provide the best possible protection to the soil, the greatest variety and quality of forage, and the highest grazing capacity. Therefore, information describing generalized range conditions and sites will give an indication of runoff, sedimentation, and general value of the timber and forage resource.

Rangeland has been divided into about 17 major range sites and two woodland sites, (table 7). The sites are distinctive and vary by climate and location from the desert area through the brush and timber zone to the alpine area above timberline.

Desert Sites

The area of soil mapping units 1 and 2 contain the desert range sites such as Clayey Salt Desert, Shaley Salt Desert, Loamy Salt Desert and Salt Desert Breaks. Distinctive vegetation consists of Mat and Gardner saltbush, shadscale, bud sage, galleta grass, Indian ricegrass, western wheatgrass and squirreltail.

These desert lands are used predominantly for winter and spring grazing by cattle, sheep and deer. Many bands of sheep traverse this area as they move from summer to winter range. Most of these migratory sheep bands are owned by ranchers with operating headquarters outside of the Basin. The area is also on the path of a large migratory deer herd that moves back and forth from summer to winter range. The permanent deer herd is small.

Range condition varies from fair to poor. Twenty acres or more are required to provide an animal unit month of grazing. Management of the range requires restricted spring and summer grazing, beginning early in the spring, to give grasses and desirable shrubs a good start. Controlled winter grazing would reduce undesirable brush and increase grass cover, if livestock were removed in the spring until range is ready for summer grazing. Most of the range is managed by the Bureau of Land Management.

Table 7.--Range and woodland sites by soil mapping units, White River Basin in Colorado

Range sites, woodland group or land type	Soil mapping unit									Total
	1	2	3	4	5	6	7	8	9	
	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Grazing lands										
Clayey Salt Desert	39,300	8,800								48,100
Shaly Salt Desert	39,300									39,300
Salt Desert Breaks	11,300	105,400								116,700
Loamy Salt Desert		35,100								35,100
Rocky Foothills			199,000	2,200	90,200					291,400
Rolling Loam			159,200	13,400						172,600
Salt Flats	5,600		39,800	4,500						49,900
Shallow Foothill			79,600							79,600
Clayey Foothill			39,800	4,500						44,300
Pinon-juniper 1/			159,200							159,200
Brushy Loam				2,200	208,000					210,200
Deep Loam				13,400	173,000					186,400
Loamy Slopes				4,400	69,000					73,400
Mountain Loam					104,000			3,500		107,500
Shallow Loam						7,600	24,300	9,100		41,000
Subalpine Loam						15,200				15,200
Aspen Woodland 1/							16,800			16,800
Alpine Slopes									12,700	12,700
Alpine Meadow									6,900	6,900
Inclusions	11,300	8,800	39,700		20,800	3,200				83,800
Rock outcrop and badland	5,600	17,600	79,500		13,900	3,000	7,300	1,400	3,400	131,700
Total grazing land	112,400	175,700	795,800	44,600	678,900	29,000	48,400	14,000	23,000	1,921,800 2/
Timber and grazing lands										
Aspen woodland 1/						16,000	169,000			185,000 3/
Total	112,400	175,700	795,800	44,600	678,900	45,000	217,400	14,000	23,000	2,106,800

1/ Woodland site.
2/ Includes 41,500 acres of grazing in the Flat Tops Primitive Area.
3/ Includes 4,000 acres of timber and grazing lands in the Flat Tops Primitive Area.

Source: USDA Field Party

Runoff from summer storms is the dominant type of water yield from this area. Floods deposit heavy sediment loads through small drainageways to the main White River. The range is mostly in poor or fair condition which indicates low vegetative cover and high erosion. Snows are infrequent but the rapidity of melting and runoff, particularly spring snows, causes much erosion and sediment. Range reseeding is difficult because of the dry climate and soil limitations. The best method of improving range condition in these mapping units is proper use over a long period of time. Erosion is a definite hazard in this area. The Bureau of Land Management classified some of this area as "Frail Watershed Land." 1/

Foothill Sites

Soil mapping units 3, 4, and 5 contain most of the foothills or brush range sites. They provide most of the grazing within the Basin. Rangelands are associated with and adjacent to cultivated lands and ranch headquarters. Most of the rangelands in mapping unit 4 are privately owned but in units 3 and 5 most rangelands are managed by the Bureau of Land Management. Private rangelands are concentrated east of a line from Rio Blanco to Price Creek.

Rangelands in soil mapping units 3, 4, and 5 contain the following major range sites: Rocky Foothills, Rolling Loam, Salt Flats, Shallow Foothill, Clayey Foothill, Brushy Loam, Deep Loam, Loamy Slopes and Mountain Loam. Interspersed within these range sites is a Pinyon-Juniper woodland site.

The general aspect of these rangelands is brush with an understory of interspersed grasses. Big sagebrush is the distinguishing vegetation. Oak brush is characteristic on some of the soils and elevation zones. Serviceberry, mountain mahogany and snowberry are other brush types. Pinyon pine and Utah juniper dominate the Shallow and Rocky Foothill sites. Salt Flats contain greasewood but it is limited to conditions caused by high water table. Grass understory consists of western wheatgrass, Indian ricegrass, native bluegrass, and Junegrass. These grasses have decreased under heavy use and brush has increased.

1/ Frail watershed lands as described by the Bureau of Land Management in their report, "A Preliminary Study and Report on Frail Watershed Lands" are those lands that, because of one or more factors, such as steepness of slope, nature of soil, plant-cover condition or possibly other factors, are highly susceptible to erosion.

Productivity varies by individual range sites. Generally 10 to 20 acres are required per animal unit month of grazing. Average range condition is fair. With application of good range management practices, the range condition could be raised to good condition and forage yield increased. Grazing management would include proper distribution of livestock aided by location of water developments, trails, fences, and salting ground. Many of these ranges are low on grass forage and high on sagebrush, so sagebrush control of adapted areas would improve range condition and forage yield.

Utah juniper trees are prevalent in soil mapping units 3 and 5. Trees have invaded the grazing area and reduced forage production in certain areas. Removal of trees by chaining or other methods would improve forage production on areas of deeper soils. In other places the trees are a natural plant community and are described as a woodland type. These areas should be managed for production of wood products such as fence posts and firewood. Woodland areas also provide excellent protection for wintering livestock.

Pinyon-juniper woodland
(Soil Mapping Unit 3)

There is a small acreage of timber land predominantly Douglas fir. Lumber is being harvested but the areas are so small and scattered that systems of management for sustained yield are not practical. Clear-cutting is the general rule with a waiting period for regrowth. The cost of moving in and out and the low timber value preclude the use of selective cutting.

There are 4,200 acres of recreation land in these three soil mapping units. Most of the installations are camping or picnicking sites on state and Federal lands. Some private lands have developed picnic, camping or cabin areas.

Montane Sites

Soil mapping units 6 and 7 are the timber and grazing area and are principally within the White River National Forest. Range sites are described on grazing or timber and grazing land. Forested areas are described as timber land. Grazing sites include Mountain Loam, Shallow Loam and Subalpine Loam. There are also small areas of Mountain Meadow range sites which are quite productive.

Well managed high country range

There are small acreages of private range interspersed with Federal land. Grazing on Federal land is controlled to keep range in good condition. Small areas exist where livestock or wildlife concentrate and additional controls are needed. Private range is heavily used to fill in between grazing on cropland and turn-on and turn-off time on Federal land.

Vegetation that distinguishes these areas are big sagebrush, aspen woodland, spruce, fir and grasses. Grasses are usually bluebunch wheatgrass, Thurber fescue, mountain brome, Columbia needlegrass and tufted hairgrass.

Range production is high, the majority of the land averaging 2 to 8 acres per animal unit month of grazing, and the remainder averaging 8 to 15 acres per animal unit month.

The timbered areas of soil mapping unit 6 are very good to excellent spruce-fir timber sites. Mature trees commonly range from 5 to 7 logs in height. In 1948 the Engelmann spruce beetle epidemic killed the merchantable Engelmann spruce on the entire White River drainage. The areas of dead spruce now support excellent stands of Engelmann spruce and subalpine fir reproduction. This timber will reach merchantable, pulpwood size before the year 2000. Under good timber management practices, it will reach sawtimber size by the year 2020. Many of the stands of aspen are the result of past fires and are growing on good to very good spruce-fir timber growing sites.

The scattered stands of Douglas fir in soil mapping unit 7 on Piceance Creek and Douglas Creek drainages occupy fair to poor timber sites. These Douglas fir stands are of a quality that make them more valuable for watershed, wildlife habitat, and recreation than for the production of merchantable timber.

Precipitation is high within these mapping units. Snow accumulates over a long season and melts slowly, providing a sustained streamflow. There are few opportunities for the initiation of snow manipulation projects to improve the water yield. In the timbered areas, lack of mature timber precludes the use of managed timber harvesting practices to increase streamflow. Sediment production from these units is low because of the good vegetative cover. Most of the water yield and streamflow in the White River comes from these mapping units and unit 9.

Large areas are used for recreation but this is only one of the uses. A smaller area developed for cabins, campsites, and picnic grounds is classed as recreation land. A large herd of elk and deer graze

rangelands along with cattle and sheep. The Flat Tops Primitive Area has about 58,000 acres in these soil mapping units. The Primitive Area is restricted as to commercial activities.

In soil mapping unit 8, the Cathedral Bluffs are the most predominent feature. This geologic exposure may become a recreation attraction. The unit is located in the western part of the watershed at lower elevations and has minor snow accumulation and lower rainfall. Small amounts of sediment are produced as the erosion is mostly geologic. Range sites include Shallow Loam and Mountain Loam. Grazing management is in conjunction with mapping units 3, 5 and 7.

Alpine Sites

Soil mapping unit 9 is the alpine area of the Basin. It is used for grazing and water yield. Two range sites were described as Alpine Slopes and Alpine Meadow. The remaining area consists of bare rock outcrop, rock slides and steep escarpments. Vegetation is typically arctic types of tufted hairgrass, alpine timothy, alpine willow, and sedges in the meadows and alpine bluegrass, alpine clover, and kobresia on the slopes.

Range condition is good to excellent and is grazed by sheep and elk. All of the area is within the national forest. Productivity ranges from 1.5 acres per animal unit month to 12 acres per animal unit month. The grazing season is short.

High water yields result from these locations. Large alpine snowdrifts require most of the summer to melt. Precipitation averages more than 30 inches annually.

All of this unit lies within the Flat Tops Primitive Area and is used for sightseeing, fishing, horseback riding, hiking and other forms of recreation. This area is the summer range for the White River elk herd.

Phreatophytes

There are 3,845 acres with a cover of nonbeneficial phreatophytes [1] and 355 acres of nonproductive seeped land in the Basin (table 8). Four predominant types of phreatophytic vegetation were surveyed; i.e., sedges and rushes, greasewood, willows, and cottonwood. Cottonwood, willows, sedges and rushes occur throughout the Basin. White greasewood is confined to the lower warmer areas.

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[1] In this report "nonbeneficial phreatophytes" are nonagricultural plants that obtain their water supply from the zone of saturation. They have little or no beneficial use.

Table 8.--Phreatophyte acreage, White River Basin in Colorado, 1964

Plant species	Vegetative cover: Light	Medium	Dense	Total
	Acres	Acres	Acres	
Sedges and rushes (Carex spp. and Juncus spp.)	0	0	2,410	2,410
Greasewood (Sarcobatus vermiculatus)	0	0	135	135
Willows (Salix spp.)	0	0	305	305
Cottonwood (Populus spp.)	85	585	325	995
Total	85	585	3,175	3,845
Seeped lands				355

Source: USDA Field Party

To obtain data that could be interpreted in terms of estimates of consumptive water use, the area occupied by phreatophytes was surveyed and classified by density of vegetative cover. Classes used are light, medium, and dense. These were applied separately to each species. Since wet areas are generally associated with phreatophytes, seeped lands were also delineated.

There are no widespread programs of control of phreatophytes in the Basin. Some individual land operators are clearing lands for hay or pasture. Phreatophytes are using water but probably only a small part of this water can be salvaged. Under improved land management, some phreatophytes might be replaced by plants that would provide a return to the land operator. In some instances cottonwood and willows should be maintained to provide protection or shade for livestock and recreation areas.

Consumptive use of water by phreatophytes, riparian vegetation, seeped lands and other incidental areas is estimated in a succeeding section of the report.

Flood Damages

The erratic random pattern of intense summer thunderstorms results in occasional local damage to agricultural or other land and improvements, or to facilities such as roads, structures, and canals. During the snowmelt season in years of heavy snow accumulation, extensive flooding of low lying lands occurs. At such times, there is damaging scour and erosion of fields and stream channel banks. Early spring thaws frequently cause ice jams that result in damages in the vicinity of Rangely. Farm improvements have generally been so located as to minimize the danger of flood damage. The same is true of towns and settlements in the Basin.

Flooding along the White River
above Rangely caused by ice jams in 1962

At some locations, notably the wet meadows in the vicinity of Meeker, spring flood waters constitute the early irrigation. In some cases, they provide a major part of the water supply for hay and pasture growth. Areas with deficient irrigation water supplies generally benefit from the regular spring flooding. They might well be at some disadvantage if it were eliminated.

The USDA Field Party inspected all tributary drainages within the Basin, using the Conservation Needs Inventory and maps as a guide. Numerous locations were noted where isolated flood damages had occurred or where there was an apparent flood damage potential. With few exceptions, however, these were of limited extent and involved single fields, individual landownerships or obviously unfavorable cost-benefit relationships, or they were otherwise not suited for flood prevention project action under the provisions of Public Law 566. There have been two Public Law 566 project proposals within the Basin. Upon reconnaissance inspection, they were found to lack justification on the basis of cost-benefit relationships.

Water Use

The average annual depletion of the Basin water supply during the 1943-60 period was about 38,400 acre-feet. This is exclusive of on-site use by native forest and range vegetation. Water resource depletions, as used in this report, are estimates of water consumptively used relative to man's activities and do not represent the total amount of water diverted from natural stream flows.

The major use of water is for irrigation. Net consumptive use on irrigated lands [1] is over 76 percent of the total water depletion. Nearly 95 percent of the irrigated land was used for production of hay and irrigated pasture. Net consumptive use by irrigated crops was computed by Blaney-Criddle procedures based on climatic records and average crop acreage distribution for the 1943-60 period. Adjustments were made for variations in adequacy of water supply.

Other uses amounting to 24 percent of total depletion were estimated from appropriate data and procedures. These included consumptive use on non-crop water-using areas incidental to irrigation development, use by riparian and nonbeneficial phreatophytic vegetation and

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[1] Net consumptive use on irrigated land is the amount of water, excluding effective precipitation, used in evaporation and transpiration by a crop during its growing season.

seeped land, municipal and domestic use, and evaporation from reservoirs. There are only two towns in the Basin, Meeker and Rangely, with populations greater than 1,000 persons. Average population of the Basin during 1943-60 was about 4,600 people and depletion of water due to domestic and municipal use was about 1 percent of total consumptive use.

Irrigating recently leveled cropland

Secondary recovery of petroleum in the Rangely oil field is the only major industry currently using a significant amount of water. Present consumptive use by the waterflood operation is about 9,400 acre-feet annually. This rate of use is expected to decline as the underground reservoir continues to fill, and consumptive use of water by this operation should be negligible by 1980. This operation began in 1958-59, and since appreciable amounts of water were not used until 1962-63, the depletion is not accounted for in the 1943-60 period.

There are no exports of water for use outside of the Basin at the present time. Therefore, the aggregate consumptive use related to man's activities within the Basin accounts for the total amount of depletion of the water supplies of the Basin (table 9).

Table 9.--Average annual water depletion, White River Basin in Colorado, 1943-60

Water depletions	Upper basin [1]	Lower basin [1]	Total
	Acre-feet	Acre-feet	Acre-feet
Irrigated crops [2]	21,600	7,700	29,300
Riparian vegetation, nonbeneficial phreatophytes, seeped lands, and incidental areas [3]	4,700	2,600	7,300
Industrial, municipal, domestic and livestock use, and reservoir evaporation	1,100	700	1,800
Total depletion	27,400	11,000	38,400

[1] The division between Upper and Lower Basin is shown on the water resource frontispiece.

[2] 35,200 acres of irrigated land.

[3] Estimates of water depletion resulting from riparian vegetation and nonbeneficial phreatophytes may in some instances include consumptive water use due to natural conditions that are impossible to separately identify and differentiate from man-related developments.

Source: USDA Field Party.

THE AGRICULTURAL INDUSTRY

Livestock production dominates the agricultural industry of the Basin. With the exception of wheat raised on dry cropland, all crop production is for livestock forage. The land base for agricultural production consists of approximately 452,000 acres of private crop and grazing land, 41,100 acres of state lands which are leased for grazing, and 1,680,800 acres of federal rangeland on which grazing is permitted.

The economic heart of the ranches is the 35,200 acres of irrigated land. The 1959 Census of Agriculture showed 78 percent of the farms and ranches as irrigated, indicating the importance of the water resource to the agricultural industry.

Sources of data for the 1943-60 period consisted primarily of Colorado Agricultural Statistics annual report, U. S. Census of Agriculture and Irrigation, Bureau of Reclamation Project and Crop Reports, and agricultural technicians familiar with the area. County statistics were interpolated to provide an estimate of the agricultural economy of the Basin. Comparable procedures were used in previously completed studies in the Colorado River Basin. This approach makes it possible to account for each part of the counties involved as they fit into the Colorado River Basin as a whole.

The Resource Base

Number and Size of Farms and Ranches

The number of farm and ranch operating units declined from 257 in 1944 to 179 in 1959 for a loss of 78 farms and ranches (30 percent), (table 10). The largest reduction occurred in farms with 180 to 999 acres. This reduction in numbers of farms and ranches has been accompanied by a corresponding increase in size, value of land and buildings per farm, and average acreage irrigated. Census data show that average size of farm in this Basin increased from slightly over 1,800 acres in 1944 to 3,200 acres in 1959. During the same period the average value of land and buildings per farm increased from $18,500 to $75,000. This trend toward larger farm sizes reflects the national trend of attempting to spread fixed cost over large acreages.

Table 10.--Number and size of farms, White River Basin in Colorado, 1944-59

Size of farm	1944	1949	1954	1959
	Number	Number	Number	Number
Under 50 acres	8	12	4	4
50 to 179 acres	35	30	25	19
180 to 999 acres	107	95	86	62
1,000 acres and over	107	100	111	94
Total	257	237	226	179

Source: U. S. Census of Agriculture.

The value of farm products sold is often a more appropriate measure of farm and ranch size. In this respect, approximately one-half of the farms and ranches had gross sales of over $10,000 in 1959 (table 11).

Table 11.--Farms by class of farm, White River Basin in Colorado, 1949-59

Class of farm	1949		1954		1959	
	Number	Percent	Number	Percent	Number	Percent
Commercial farms						
Value of farm products sold:						
$10,000 or more	63	26.6	79	34.9	87	48.6
$ 2,500 to $9,999	105	44.3	91	40.3	64	35.8
$ 50 to $2,499 1/	33	13.9	25	11.1	11	6.1
Total	201	84.8	195	86.3	162	90.5
Other farms						
Part-time	14	5.9	14	6.2	10	5.6
Part-retirement or residential	21	8.9	16	7.1	7	3.9
Unclassified	1	.4	1	.4	0	0
Total	36	15.2	31	13.7	17	9.5
All farms	237	100.0	226	100.0	179	100.0

1/ Provided the farm operator met census definition of a commercial farmer.

Source: U. S. Census of Agriculture.

Operators of these farms control sufficient land and capital resources to produce relatively large outputs of agricultural products. Of 87 farm operators with farm income in excess of $10,000 in 1959, 22 percent had gross sales of over $40,000 and 44 percent had gross sales of from $20,000 to $39,999. In 1959, the U. S. Census of Agriculture classified 90 percent of farms and ranches in this Basin as commercial farms as against 79 percent in the state of Colorado as a whole. Information on net farm income is not available, but data for Colorado indicates that realized net income per farm in relation to gross income was about 20 percent in 1959.

Types of Farms and Ranches

During the 1943-60 period, livestock ranches have increased from approximately 61 percent to about 81 percent of all farms and ranches (table 12). There has been a significant decrease in all other types of farms or ranches. This trend will probably continue since the resources of this Basin are best suited to extensive operations and production of livestock. Recent information indicates that there are two dairy and one poultry farms in the Basin.

Table 12.--Number of farms or ranches by type of farm, White River Basin in Colorado, 1944-59

Type of farm	1944	1949	1954	1959
	Number	Number	Number	Number
Field crop	46	31	27	10
Poultry	4	0	0	0
Dairy	8	5	1	1
Livestock 1/	159	145	147	146
General farms	14	20	19	5
Miscellaneous and unclassified	26	36	32	17
Total	257	237	226	179

1/ Other than poultry and dairy farms.

Source: U. S. Census of Agriculture.

In 1959, 139 farms (78 percent) were classified as irrigated farms, while in 1944, 165 farms (64 percent) were classified as irrigated. Thus there was a loss of only 16 percent of irrigated farms compared to a loss of 30 percent of all farms in the Basin. While part of the Basin receives sufficient moisture for production of crops on dry cropland, production is too variable to provide a reliable feed and forage supply for livestock. Since the resources of the area are better suited to the production of livestock, there is a trend towards operations which have enough irrigated land to provide a reliable supply of winter feed. The 1959 Census of Agriculture indicates that 86 percent of hay harvested was produced on irrigated cropland.

Census data for 1959 shows 32 percent of the 179 farms and ranch operators worked off-farm during the year, with 21 percent working off-farm more than one hundred days during the year, and that 22 percent of farm operators had off-farm income exceeding the value of farm sales. The number of farm operators working off-farm has remained relatively stable with from 50 to 85 farm operators having off-farm employment.

Farm and Ranch Tenure

In 1959, 54 percent of the farmers and ranchers were owner-operators and 33 percent were part-owners. The trend has been towards fewer full owners, paid managers, or tenants. The number of part-owners has remained relatively constant at about 60. In 1959, 87 percent of the farms and ranches were fully or partially owned by the operator. For Colorado 79 percent of the farms and ranches were in this category.

Agricultural Investment

Total investment in private land and buildings was about $13,434,000 in 1959. This amounts to about $75,000 per farm or $23 per acre for all privately owned land. In 1944 total investment was about $4,756,000 and the average value of land and buildings per farm was about $18,500 per farm or $10 per acre. Part of this increase in value per farm is a result of change in average size of operating unit from 1,800 to 3,200 acres. On the basis of 1960 real estate values for Colorado, 53 percent of the above increase apparently resulted from increased size of farms and ranches while the balance was a factor of increased prices. The relatively low average value per acre for privately owned lands results from 80 percent of the land in farms or ranches being used for grazing or timber and grazing. Even this low value of private land and buildings reflects some capitalized values of grazing leases or permits on federal rangeland.

Transportation

The Basin is not on any main transportation routes. U. S. Highway 40 cuts across the northwest corner of the Basin from Elk Springs to Artesia (now Dinosaur). There is a good network of state highways and county roads as shown on the highway and recreation area map following page 68. Transportation facilities have been generally adequate to meet the needs of the farm and ranch population, and towns and communities in the Basin. There is no railroad within the Basin. Therefore, livestock is shipped to central market by truck line or is trucked to the Denver and Rio Grande Western Railroad at Craig or Rifle, Colorado.

The closest scheduled airline service is provided at Grand Junction, Colorado and at Vernal, Utah. In addition, county airports at Rangely and Meeker have 4,500 foot runways and will accommodate light commercial aircraft.

Markets

Livestock is the major export from the Basin. Marketing patterns for this livestock have changed in recent years, with a rapid increase in number of sheep and cattle marketed at decentralized markets and country points, and a decline in the number marketed at the Denver terminal market. Direct country contract or auction market sales to livestock feeders and contract or order buyers now constitute the major market for livestock.

Sheep being sorted and loaded
for shipment to market

Most cattle are sold as steers or heifers followed in numbers by calves and cull cows. Calves and long yearlings are usually sold to contract or order buyers. Cull cows are often sold at auction in Rifle. A large part of the cattle from this Basin move to west coast markets.

Most sheep and lambs produced go directly to packers or are sold to feeders in northeastern Colorado and the Arkansas Valley. Some lambs are fed in irrigated areas of western Colorado mostly in Mesa, Garfield, Delta, and Montrose Counties.

Individual operators generally produce some surplus hay. This hay is sold to sheep and cattle operators for local use. The area is generally a deficit area in production of feed grains so the limited production ordinarily finds a ready market. Most of the wheat is trucked to Salt Lake City or Ogden, Utah with smaller amounts being marketed at Craig, Colorado.

Agricultural Production

Associated with the increase is size of farms and ranches in the Basin is an increase in acreage of forage crops and irrigated pasture. The trend toward livestock operations strongly indicates that livestock operators have a comparative advantage over field crop and general farms. This results in a trend toward crops which provide feed or forage for livestock.

Irrigated hay production

Irrigated and Dryland Crops

Irrigated acreage averaged 35,200 acres and dry cropland 34,100 acres during the 1943-60 period (table 13). Total cropland harvested has been relatively stable during this period, with some decrease in irrigated acreage and a corresponding increase in dry farmland acreage.

Hay of all kinds is the most important crop harvested. About 25,500 acres of hay are harvested each year. U. S. Census of Agriculture records indicate 76 percent of hay acreage is on irrigated cropland. Alfalfa hay acreage has been increasing and currently amounts to over 10,000 acres or about 40 percent of all hayland. The Basin presently produces about 37,000 tons of hay per year with an average value of over three-quarters of a million dollars. The 1943-60 average yield of all hay grown in the Basin was one and one-half tons per acre. This relatively low yield is partly a factor of climate, but it also indicates a low level of management.

Cropland pasture averaged about 20,000 acres or 29 percent of total cropland acreage during the 1943-60 period. Irrigated cropland pasture averaged about 6,000 acres and there was an average of about 14,000 acres of dry cropland pastures during this period. In addition, there was an average of about 7,700 acres of non-cropland irrigated pasture. This includes natural overflow areas, rough pastures and areas irrigated only with high waters in the spring. Use of irrigated pasture has grown rapidly in recent years as a means of off-setting a reduction in rangeland grazing and to provide a balanced livestock program.

Recent estimates indicate an acreage of 15,000 acres of irrigated and subirrigated pasture (including non-cropland areas). A considerable portion of this irrigated pasture acreage is on poorer quality land, land with a short water supply, or on fields that are small or irregular. Acreage of dry cropland pasture has been reduced somewhat during the study period by increased acreages of wheat.

Acreage of wheat increased considerably during the late 40's and early 50's. This was primarily a factor of relatively high prices from the end of World War II through the Korean War. Reestablishment of wheat acreage allotments has tended to stablize acreage of wheat at about 6,500 acres. There has been a considerable decrease in acreage of irrigated oats and barley harvested for grain. This has mostly been offset by an increased acreage of oats harvested for hay. In the lower part of the Basin there has been an increase in acreage of corn. Recent estimates indicate that about 200 acres of corn are being harvested for silage each year. Feeding operations are on the increase.

Table 13.--Average acreage, total production and gross value of principal irrigated and dry farm crops harvested, White River Basin in Colorado, 1943-51, 1952-60, and 1943-60

Crop	Unit	1943-51 Average: Irrigated land	1943-51 Average: Dry farmland	1943-51 Average: Total	1952-60 Average: Irrigated land	1952-60 Average: Dry farmland	1952-60 Average: Total	1943-60 Average: Irrigated land	1943-60 Average: Dry farmland	1943-60 Average: Total
Corn										
Harvested	Acres	24	16	40	103	37	140	64	26	90
Production	Bu. [1]	773	216	989	4,212	556	4,768	2,493	386	2,879
Value	Dol.			1,429			6,123			3,776
Winter wheat										
Harvested	Acres	182	4,160	4,342	106	5,093	5,199	144	4,626	4,770
Production	Bu.	4,630	87,745	92,375	3,128	100,651	103,779	3,879	94,199	98,078
Value	Dol.			162,172			184,833			173,505
Spring wheat										
Harvested	Acres	296	1,197	1,493	111	1,452	1,563	204	1,324	1,528
Production	Bu.	9,217	23,404	32,621	4,101	24,169	28,270	6,659	23,787	30,446
Value	Dol.			59,071			51,266			55,168
Oats										
Harvested	Acres	1,319	782	2,101	684	764	1,448	1,001	773	1,774
Production	Bu.	63,148	24,654	87,802	32,495	21,152	53,647	47,822	22,903	70,725
Value	Dol.			69,623			42,610			56,117
Barley										
Harvested	Acres	520	644	1,164	274	988	1,262	397	817	1,214
Production	Bu.	21,946	17,486	39,432	11,432	22,376	33,808	16,688	19,930	36,618
Value	Dol.			42,498			32,909			37,704
Rye										
Harvested	Acres	NA	NA	116	NA	NA	77	NA	NA	96
Production	Bu.			2,022			859			1,440
Value	Dol.			2,422			1,009			1,715
Potatoes										
Harvested	Acres	56	21	77	20		20	38	10	48
Production	cwt.	4,665	641	5,306	2,256		2,256	3,460	320	3,780
Value	Dol.			11,964			4,280			8,122
Alfalfa										
Harvested	Acres	NA	NA	8,400 [2]	NA	NA	10,008 [2]	NA	NA	9,244 [2]
Production	Tons			13,283 [2]			16,286 [2]			14,784 [2]
Wild hay										
Harvested	Acres	NA	NA	7,233 [2]	NA	NA	4,581 [2]	NA	NA	5,907 [2]
Production	Tons			11,244 [2]			6,523 [2]			8,884 [2]
All hay										
Harvested	Acres	NA	NA	25,793	NA	NA	25,200	NA	NA	25,497
Production	Tons			39,831			36,799			38,315
Value	Dol.			697,473			733,414			715,442
Fruits and vegetables										
Harvested	Acres	4		4	5		5	4		4
Value	Dol.			446			126			286
Total harvested cropland										
Harvested	Acres			35,130			34,914			35,021
Value	Dol.			1,047,098			1,056,570			1,051,835
Cropland past.	Acres	4,983	17,877	22,860	7,055	10,109	17,164	6,020	13,993	20,013
Other crop. pasture and idle land	Acres									14,266
Total cropland	Acres							(35,200)	(34,100)	69,300

[1] Converted to grain at the approximate rate - 1 ton silage = 5 bu. grain

[2] Included in "All hay"

Source: Colorado Agricultural Statistics and U. S. Census of Agriculture.

Dry cropland east of Meeker

No high value crops are produced. Gross values of all crops harvested remained at about $1,051,000 during the study period. Average value per crop acre harvested is $30 in comparison with average values of $60 in the Colorado River Basin in Colorado.

Range and Pasture Lands

The 1,476,000 acres of grazing lands administered by the Bureau of Land Management provide approximately 178,800 animal unit months of grazing per year (table 14). These lands are all a part of the Craig District Management unit and are mostly supervised by the Meeker sub-office. At present 81 operators have licenses or permits for 23,614 head of cattle or horses for a total of 96,700 animal unit months of grazing, and 58 operators have licenses or permits for 151,494 head of sheep for a total of 82,100 animal unit months of grazing on Bureau of Land Management administered lands.

Table 14.--Grazing use by livestock, White River Basin in Colorado, 1964

Source	Grazing
	Animal unit months
Rangeland	
National forest lands [1]	32,500
Bureau of Land Management lands	178,800
State land [2]	6,800
Private	64,200
Total rangeland	282,300
Cropland	
Irrigated pasture and cropland grazing	48,100
Dry cropland and planted pastures	17,400
Total cropland	65,500
Total	347,800

[1] Forest Service animal months converted to animal unit months of grazing.

[2] State School Lands 20,500 acres and Colorado Game, Fish and Parks Commission Lands 20,600 acres.

Source: Data furnished by the Bureau of Land Management, Forest Service, and Soil Conservation Service.

Approximately 204,800 acres of the 354,000 acres of national forest lands in the Basin are suitable for grazing by domestic livestock. These lands are all within the Blanco Ranger District of the White River National Forest, and provide approximately 32,500 animal unit months of grazing annually. In 1964, 40 permittees had permits for 4,696 head of cattle or horses for a total of 16,600 animal unit months, and 30 permittees had permits for 33,880 head of sheep for a total of 15,921 animal unit months of grazing.

Domestic livestock carrying capacity of the approximately 426,000 acres of private or state-owned grazing land is estimated to be 71,000 animal unit months of grazing annually. The majority of these grazing lands are found adjacent to ranch headquarters and are used for early spring and late fall grazing.

An estimated 76 percent of the rangeland of this Basin is in good or fair condition. For present conditions, it is estimated that proper use of the rangeland would be about 274,000 animal unit months of grazing. This is about 3 percent less than the estimated present use. Therefore, the main problem is distribution of livestock and management of the grazing resource. In addition to rangeland grazing, it is estimated that under present conditions livestock obtain about 65,500 animal unit months grazing from pasture (irrigated or dryland) and cropland grazing. If livestock production is to expand, irrigated pastures and cropland grazing (early spring, crop aftermath, and field residues) will have to be major sources of increased forage. Increased recreational use, wildlife numbers and loss of rangeland to urban, municipal and highway development will tend to offset potential increases in range productivity.

Livestock

The importance of the livestock industry as a means of marketing much of the crop and pasture production has been emphasized in preceding sections of this report. Census data for the 1944-59 period provide an indication of trends in livestock numbers and use of crop and pasture by various kinds of livestock (table 15). The data are not completely comparable because the 1959 and 1954 censuses represent fall inventories, the 1950 census was as of April 1, and the 1945 census was as of January 1. Sheep and cattle numbers have been relatively stable for ranches headquartered within the Basin. There has been a considerable decrease in number of milk cows, horses, hogs and chickens.

Table 15.--Livestock numbers, White River Basin in Colorado, 1945-59

Type of livestock	1945 (Jan. 1)	1950 (April 1)	1954 (Fall)	1959 (Fall)
	Number	Number	Number	Number
Cattle and calves	26,478	25,418	34,346	27,077
Cows including heifers that have calved	15,289	12,694	17,052	13,849
Milk cows	856	653	499	401
Horses and/or mules	2,849	2,401	1,525	1,440
Hogs and pigs	850	665	658	327
Sheep and lambs	55,890	44,817	64,665	63,444
Ewes	52,416	43,044	47,731	50,775
Chickens 4 months old and over	11,737	7,733	8,011	5,196

Source: U. S. Census of Agriculture

During the 1943-60 period, an average of about 31,000 animal units of livestock were headquartered within the Basin. This livestock uses an estimated 258,000 animal unit months of grazing plus an estimated 115,000 animal unit months of winter feed produced on cropland. The balance of grazing produced (91,300 AUM's) is used by livestock operators not headquartered within the Basin. This use is mostly by migratory bands of sheep.

Agricultural Income

In 1959 agricultural income from sale of all farm products amounted to about 3.3 million dollars (table 16). Income from sale of all livestock products amounted to 3 million dollars or 90 percent of the agricultural income in 1959. In 1944, income from sale of all livestock products was 88 percent of total sales of 1.8 million dollars. Average sales per farm increased from $7,140 in 1944 to about $18,500 in 1959.

The value of farm products sold and selected farm expenses were converted to 1960 dollars to remove the factor of inflation (table 16). In terms of 1960 dollars the Basin has maintained a sales value of about 3 million dollars and a value of selected farm expenses amounting to about one and one-half million dollars. Value of sales per farm in terms of 1960 dollars increased from $11,865 in 1944 to $14,360 in 1959. Thus, while actual dollar income increased by 159 percent, the increase in terms of constant dollars was only 21 percent.

The value of field crops sold averaged $313,700 during the study period. During this period the average value of all crop production was about $1,051,000 (table 13). The difference of $737,000, or 70 percent, is a measure of value of crops fed to livestock on farms where they were raised.

No commercial fruit and vegetable farms exist in this Basin and sale of forest products or horticultural specialties is insignificant.

In 1959 the all-family median income for Rio Blanco County was $5,888 while the farm-family median was $3,477. Recent studies for similar area beef ranches in northern Nevada [1] indicate that to produce annual operator earnings of $3,500 requires gross sales of about $17,000 and an investment capital of nearly $100,000.

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[1] Resource Requirements on Farms for Specified Operator Incomes, Agricultural Economics Report No. 5, USDA, Economics Research Service.

Table 16.--Selected income and expense data, White River Basin in Colorado, 1944-59 dollars and 1960 constant dollars

Item	1944	1949	1954	1959
	Dollars	Dollars	Dollars	Dollars
Value of farm products sold by source:				
Field crops	163,441	464,745	314,967	311,630
Vegetables	0	0	88	0
Fruits and nuts	483	408	0	164
Total crops	163,924	465,153	315,055	311,794
Poultry and poultry products	17,656	14,583	15,743	7,554
Dairy products	36,263	32,481	43,714	28,824
Livestock and livestock products [1]	1,613,860	2,228,593	2,280,462	2,963,563
Total livestock and livestock products	1,667,779	2,275,657	2,339,919	2,999,941
Forest products and hort. specialties	2,676	1,160	2,420	1,120
Total farm products	1,834,379	2,741,970	2,657,394	3,312,855
Sales per farm	7,140	11,570	11,760	18,500
Selected farm expenses [2]	NA	1,351,563	942,709	1,496,823
Expenses per farm	NA	5,700	4,170	8,360
	1960 Dollars	1960 Dollars	1960 Dollars	1960 Dollars
Value of farm products sold by source in terms of 1960 dollars:				
Total crops, for. prod. & hort. spec.	169,900	433,800	245,000	331,600
Total livestock and livestock products	2,879,600	2,317,300	2,772,300	2,881,400
Total farm products	3,049,500	2,751,100	3,017,300	3,213,000
Sales per farm	11,865	11,607	13,350	14,360
Selected farm expenses in terms of 1960 dollars [2]	NA	1,500,230	980,420	1,496,800
Expenses per farm	NA	6,330	4,340	8,360

[1] Other than poultry and dairy products.

[2] Feed, livestock purchases, machine hire, hired labor, gas and fuel, seeds and plants--for 1954 livestock purchases, and seeds or plants are not included.

Source: U. S. Census of Agriculture and Statistical Reporting Service.

RECREATION

Outdoor recreation resources and opportunities are adequate to meet present needs and demands. The potential for development of additional recreation resources and facilities is high.

The Basin provides most types of outdoor recreation associated with the western United States. These vary from recreation activities of the western deserts, to those associated with alpine mountains. The Basin is particularly noted for its big game hunting (mule deer and elk), trout fishing (lake and stream), horseback riding, camping, and hiking. Overall, the landscape is one of sharp contrast and scenic interest, featuring a great variety of native vegetation.

There are about 82,000 acres of the Flat Tops Primitive Area in the eastern end of the Basin (map, following page 68). This is an outstanding quality wilderness-type area that is widely known and protected from commercial development. It was named after its mountain peaks, which are capped with lava and have been geologically eroded to give mesa or "flat top" profile. The South Fork of the White River was studied, and highly rated, for designation as a Wild River by the Mid-Continent Wild Rivers Study Team in 1964.

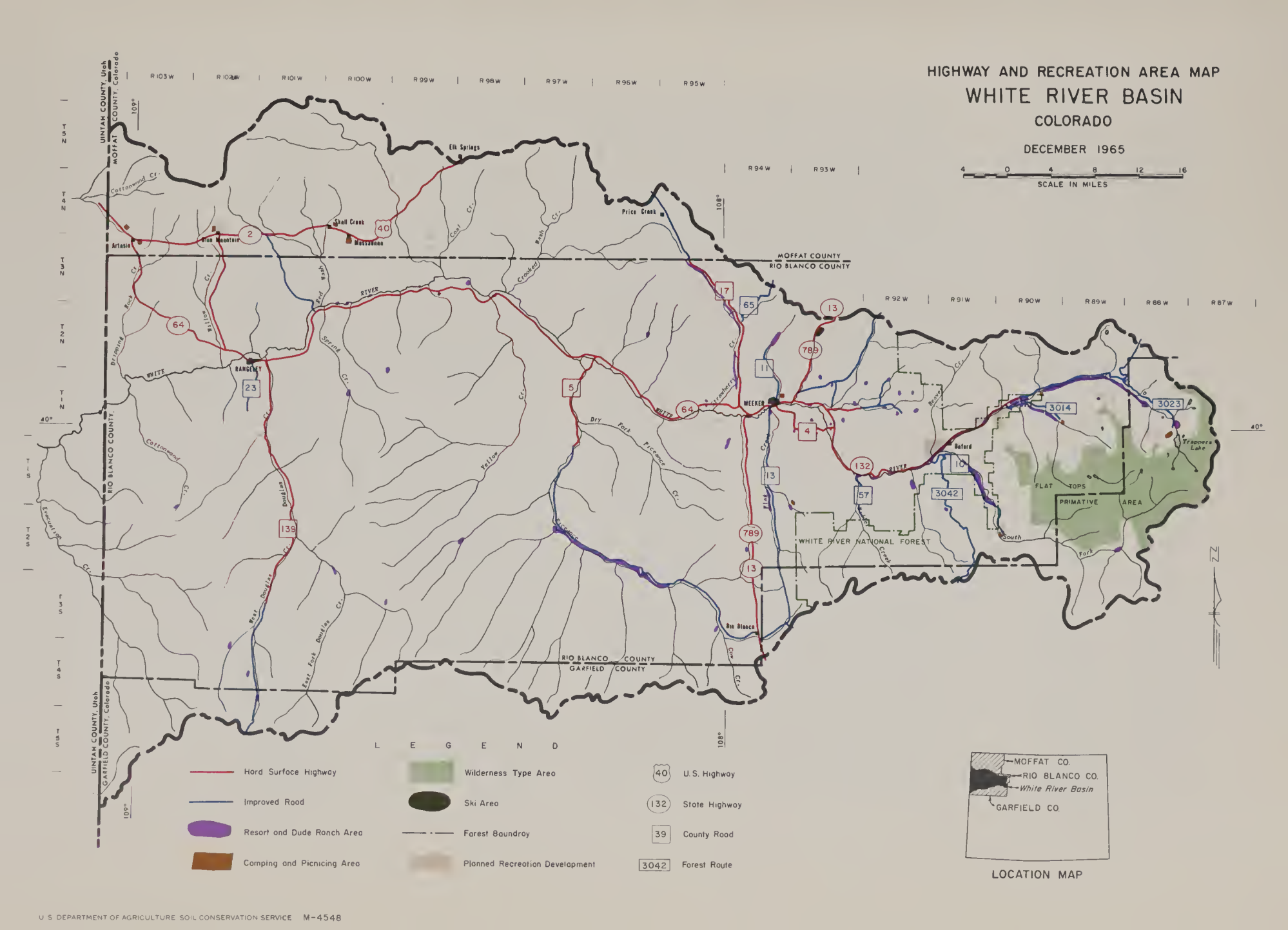
Flat Tops Primitive Area

The land use survey of the Basin shows that 7,200 acres of land is used exclusively for recreation. This includes developed camp grounds, resorts, tourist motels, developed fishing waters, and land for fish and game research. Practically all lands in the Basin provide some recreation use in addition to one or more other uses. The upper part of the White River Basin is an attractive area and a considerable acreage of the private land has been purchased for summer home sites and outdoor recreation uses.

Many ranchers in the Basin have recognized the income producing potential of recreation activities and grant hunting and fishing privileges for a fee. Some have developed resorts that specialize in providing guide service, cabins, meals, and horses for riding and packing. Almost all ranches in the Basin have some income-producing hunting facilities for the fall big game hunt.

Cabins for rent along the White River

Tourism is an important element in the economy of the Basin. Most tourists come to the White River Basin for specific recreation purposes. They plan to spend time at a particular location which provides



U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE M-4548

facilities for the desired type of recreation. Use of tourist accommodations in 1963 was estimated to be 51,840 visitor days for motels and hotels and 16,650 visitor days for camp and trailer courts.

There are 15 commercial guest ranches and resorts presently operating in the Basin, with an average accommodation of 22 guests each. Average stay is 5 days per guest and total use is about 12,000 visitor days annually.

Hunting

Big game hunting (table 17) presently constitutes the greatest recreational activity in the Basin. Hunter days increased from 64,314 in 1956 to 108,548 in 1964. One of the reasons is that the Basin has the largest migratory deer herd in the United States and the largest elk herd in Colorado. Multiple deer licenses, up to three per individual, have been issued to both resident and nonresident hunters for some management areas. Deer kill ranged from 11,550 in 1956 to 26,400 in 1963 and elk from 613 in 1958 to 1,872 in 1964. Antelope hunting is not important with only about 20 permits issued per year in recent years.

Estimated expenditures in Colorado by hunters who hunt in the Basin increased from $303,270 for licenses and $1,440,600 for other needs in 1956, to $952,800 for licenses and $9,066,530 other expenditure in 1963. Average for this period is approximately $528,500 for licenses and $3,790,000 for other expenditures. These expenditures average about 28 dollars per hunter for licenses and 202 dollars per hunter for other.

Small game include cottontail rabbits, sage grouse, blue grouse, chukar partridge, pheasants and waterfowl. About 100 hunters average three days each in hunting sage and blue grouse. Chukars are hunted approximately three times as heavily as grouse, or 900 hunter days each season. Waterfowl hunting is estimated to be 300 hunter days. Cottontail rabbits are hunted about 2,000 hunter days. The combined total for small game was about 3,500 hunter days in 1965.

Winter Sports

Skiing is not presently an important activity. There is a ski club at Meeker with 40 members. A rope tow on 9-mile hill north of Meeker, is operated by club members during the winter. Capacity is about 100 skiers per day. Average use is about 15 per day for a 120 day season.

Table 17.--Big game hunting, White River Basin in Colorado, 1964

Type of license	Hunters	License	Kill	Hunter expenditure [1]		
				License	Other [2]	Total
	Number	Number	Number	Dollars	Dollars	Dollars
Deer						
Resident	8,294	9,753	5,212	69,500	736,180	805,680
Nonresident	9,086	15,003	9,411	407,820	2,820,110	3,227,930
Total	17,380	24,756	14,623	477,320	3,556,290	4,033,610
Elk						
Resident	4,189	4,189	1,401	41,890	521,240	563,130
Nonresident	1,261	1,261	471	63,050	512,940	575,990
Total	5,450	5,450	1,872	104,940	1,034,180	1,139,120
Bear			14			
Grand total	--- [3]	---	---	582,260	4,590,470	5,172,730

[1] Estimated expenditure in Colorado by hunters that hunted within the Basin.

[2] Approximately 40 percent spent for clothing and equipment and 60 percent spent for meals, lodging, travel, entertainment, etc.

[3] Duplication exists in hunter numbers since most elk hunters also hunt deer. Bear may be taken on all big game licenses or on special spring licenses.

Source: Developed from data furnished by Colorado Department of Game, Fish and Parks.

Fishing on Trappers Lake

Fishing

The White River and its tributaries, and numerous lakes within the Basin, provide excellent fishing. Some lakes, such as Marvine, are accessible only by trail. Trappers Lake is the best known fishing water in the White River Basin and is accessible by auto road. This lake and its shore and feeder streams provide an outstanding native trout fishery, fishing from the shore and boat, surface for use and hunting of waterfowl, scenic vistas and photographic opportunities, row-boating and sailing and camping. Near the lake is a concessionaire with 16 cabins, 22 boats, and about 15 horses for rent. Special studies on Trappers Lake have been conducted by the Colorado Game, Fish and Parks Department for several years (table 18). Special regulations are imposed governing size, limits, and type of lures used at this lake. Fishermen are checked in and out, to provide research data. The total number of fishermen was estimated to average 6,000 annually during the 1960-64 period. Other lakes

for which records of annual fishing pressure are available are Wall Lake 200 fisherman days, Little Trappers Lake 300 fisherman days, and a group of small lakes near Trappers Lake with 500 fisherman days total.

Table 18.--Estimated fishing pressure, Trappers Lake, White River Basin in Colorado

Year	Fishermen	Fish caught	Hours fishing
	Number	Number	Number
1960	5,000	12,000	26,000
1961	6,000	13,000	25,000
1962	8,000	21,000	37,000
1963	5,000	13,000	35,000
1964	6,000	10,000	30,000
Average	6,000	14,000	31,000

Source: "Cut-throat Trout Investigation at Trappers Lake" and additional data, Federal Aid Project F-18-R-3, Colorado Department of Game, Fish and Parks.

At present, stream fishing pressure is estimated to average about 57,000 fisherman days annually. Stream fishing is available from the headwaters of the White River to about 10 miles below Meeker. Some special checks and creel census for selected years show 241 fisherman days per mile in 1956 to 429 fisherman days per mile in 1962. Average fishing time is usually about three hours per fisherman. Fish caught has averaged about one fish per hour.

Private resorts have filled a demand for a place to fish. About 14 resorts have fishing available on the White River, tributary creeks or ponds. Privately controlled ponds and lakes provided about 500 fishing days in 1963. About 40 private ponds have been stocked. Some owners rent fishing rights, others allow fishing rights with cabin or other rental facilities, and still others give fishing privileges by permission. Fishing water development has increased over the last twenty years, and an increased demand for this type of recreation development is forecast.

PROJECTED RESOURCE DEVELOPMENTS

This survey does not attempt to project all developments in the Basin, but rather to estimate probable changes in water and related land use after consideration of resource limitations and institutional restrictions.

Information supplied by the Colorado Water Conservation Board provides the most authoritative information available regarding potential oil shale and other resource developments within the Basin. Some estimation is provided of probable time scales associated with various stages of development. These data have been used extensively by the Field Party in estimating the potential magnitude of future changes in demands on water and related land resources of the Basin.

Bureau of Mines photo

Bureau of Mines Oil Shale Demonstration Plant near Rifle

Oil Shale

The most extensive undeveloped natural resource of the Basin is the oil shale deposits contained in the Green River Formation. These cover an area of some 2,600 square miles in northwestern Colorado and extend broadly into Utah and Wyoming. The Piceance Creek deposits in the White River Basin are the most thoroughly explored of these and are the richest known in oil content (map, following page). They cover about 1,350 square miles, with thicknesses ranging up to 2,000 feet and oil content averaging about 25 gallons per ton of shale. Oil reserves in this area amount to more than one trillion barrels, about half the total shale oil reserves of the United States and a third of those of the entire world as presently known.

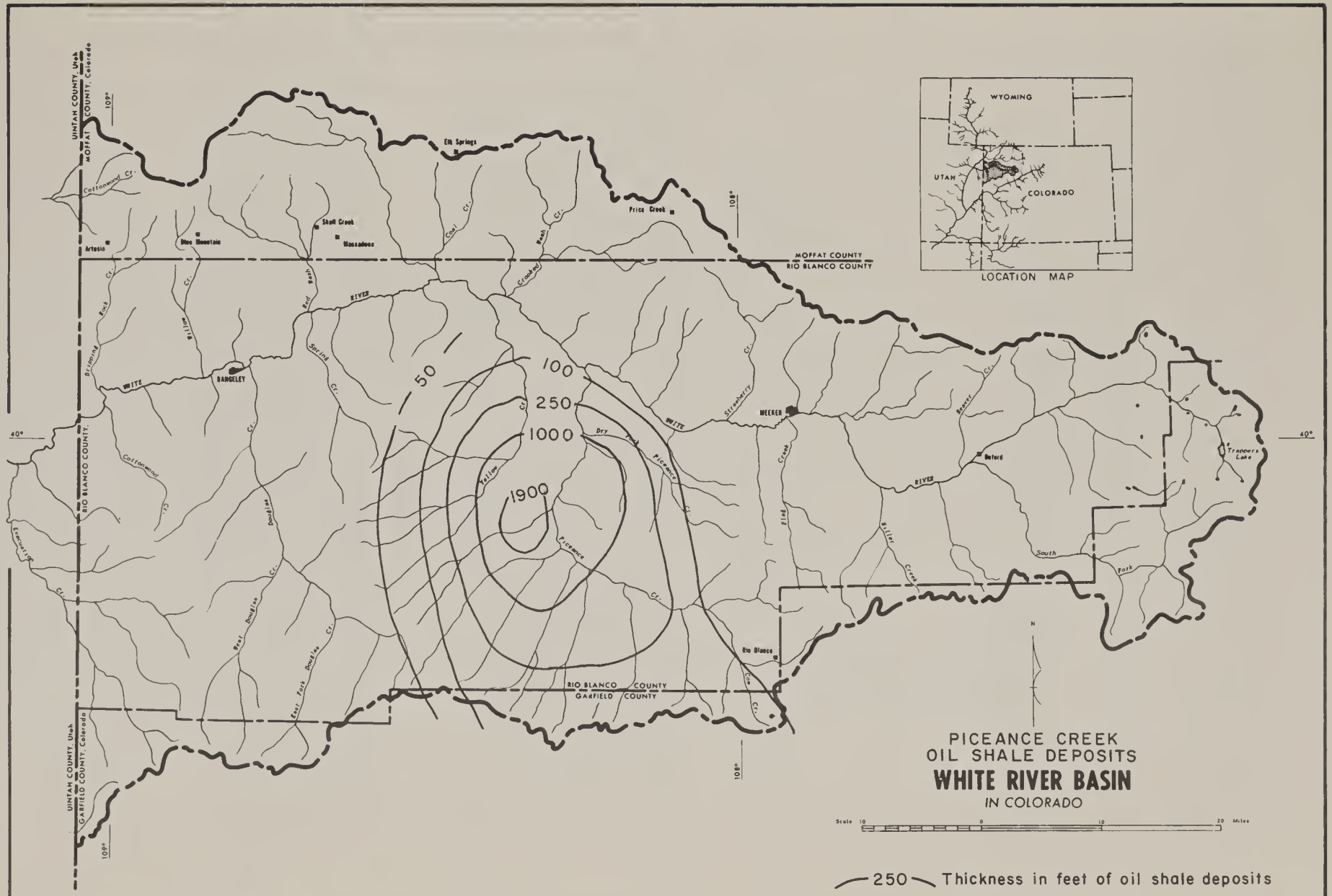
The national demand for petroleum products is increasing at a rate of about 7 percent a year. Present proven reserves of petroleum in the United States are estimated at about 31 billion barrels, and annual depletion at about four billion barrels. Requirements of the United States are estimated to triple by the year 2000. Demand in the rest of the world is increasing at a greater rate and competes with the United States for existing reserves.

Development of the oil shale resource has been initiated by several major producers on an experimental basis. Much research and development of extractive processing has been done, but not all problems of mining, oil extraction, and refining have been adequately solved to an extent that would permit immediate full development of the resource under today's economic and political conditions.

Population Projections

Changes in land and water use are closely related to growth, distribution, and income characteristics of the Basin's population and of the State and region. Population projections are based on information supplied by the Colorado Water Conservation Board and other sources (table 19). It is assumed that natural resources will be more fully utilized in the future and that the desirable climate, recreation potential, available water supplies, and mineral resources such as oil shale and coal, will lead to an extensive immigration to the Basin during the next fifty years.

This Basin is somewhat isolated and at present has a very low population density (1.5 people per square mile). Indications are that with oil shale and other industrial developments, the growth rate will be extremely rapid during the next fifty years. Since there is only a



Data from Colorada Natural Resources Division and Water Conservation Board

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OREG. 1965 M-4341

small resident population, the influx of people to work in oil shale developments could lead to serious land and water use problems. A master plan for required commercial and residential development should be worked out and necessary zoning and other restrictions instituted before problems develop.

Table 19.--Historical and projected proulation, White River Basin in Colorado, 1940-2020

Year	Estimated population
	Number
1940	3,070
1960	5,560
1980	20,000
2000	186,000
2020	204,000

Source: U. S. Census of Population, Colorado Water Conservation Board and USDA Field Party.

Projections of population resulting from oil shale development are based on the assumption that shale-oil production in the White River Basin would be 1,000,000 barrels per day by the year 2000. The 198,000 increase in population by 2020 is an estimate of the number of workers that would be directly employed in all phases of the production of oil from shale by presently feasible processes, together with their families, plus the associated service and supply enterprises that will be required by a population of this magnitude, adjusted to reflect an estimate of the proportion of this total which could be expected to reside outside of the Basin.

Adjustments in Land Use

Agriculture in the United States is in a period of rapid adjustment. This Basin has not experienced the full impact of this change because of distance from large urban centers and stability of the local livestock industry. If projected recreational, industrial, and agricultural developments occur during the next fifty years, changes in the Basin will be phenomenal. Careful planning of changes in land use can materially aid in making adjustments. Zoning, in particular, should not be overlooked as a legal technique in guiding future orderly growth.

The most significant characteristic of land use is that 77 percent of the land in in Federal ownership. The 354,400 acres within the White River National Forest is managed under multiple use principles. Foreseeable change in land use will be for additional recreational use and developments, and some increased supply and harvest of lumber and wood products as present timber matures. Some of the 1,523,900 acres of land administered by the Bureau of Land Management will probably move into private ownership within the next fifty years. A large part of the 25,100 acres outside the Craig District is in isolated tracts and probably will be transferred to State or local government for public purposes or disposed of through exchange or public sale. Additional lands under the jurisdiction of the Bureau of Land Management may be sold or leased in connection with industrial and residential developments.

Agriculture is the principal user of land in the Basin, with about 89 percent being used for cropland or grazing for domestic livestock. During the 1943-60 period, total acreage of harvested cropland has remained relatively stable at about 35,000 acres per year and cropland pasture has averaged 20,000 acres (table 13). As previously noted, irrigated pasture acreage has shown a consistent increase during this period, and it is likely this trend will continue as a means of offsetting reduced grazing permits on Federal rangeland.

Projections of changes in land use were made for the year 2020 and for intervening twenty-year periods (table 20). These projections were made to permit estimation of potential consumptive water requirements and to indicate trends in land use and agricultural production.

About 23,600 acres of land in the Basin has a potential of being developed for irrigated cropland. The major part of this (19,160 acres) would be developed in connection with U. S. Bureau of Reclamation projects, principally the Yellow Jacket project. The balance (4,440 acres) would be developed by individual landowners or by reclamation of seeped lands. It is estimated the maximum acreage of irrigated cropland will be reached by 1980, with a total of about 52,150 acres.

A gradual reduction to about 47,600 acres will occur as the shale oil industry and its related developments encroach on irrigated cropland. About 11,200 acres of irrigated cropland are estimated to go out of production between 1964 and 2020. Of this amount, about 950 acres would be inundated by reservoirs, 7,150 acres would be urbanized or industrialized, and 3,100 acres would be abandoned or converted to recreational uses.

Table 20.--Present and projected land use, White River Basin in Colorado, 1964-2020.

Land use	Present	Projected		
	1964	1980	2000	2020
	Acres	Acres	Acres	Acres
Cropland				
Irrigated	35,200 1/	52,150	50,150	47,600
Dry farm	34,100 1/	27,000	25,000	24,000
Grazing	1,880,300	1,861,000	1,796,000	1,792,000
Timber and grazing	181,000	175,000	170,000	169,600
Timber	110,900	95,000	94,000	92,000
Wilderness	82,000 2/	107,000 3/	107,000 3/	107,000 3/
Recreation	7,200	8,000	18,000	21,000
Other 4/	106,300	111,850	176,850	183,800
Total	2,437,000	2,437,000	2,437,000	2,437,000

1/ 1943-60 average cropland acres.
2/ Grazing is permitted on 45,500 acres of the Flat Tops Primitive Area.
3/ It is estimated that grazing will be permitted on 55,000 acres of the wilderness use area.
4/ Includes water acres, town sites, rights-of-way, mineral lands and other miscellaneous uses.

Source: USDA Field Party

By the year 2020 the acreage of dry farmland will be reduced to about 24,000 acres from its present 34,100 acres. The major part of this will occur as a result of irrigation of presently dry croplands, and the balance by urbanization or abandonment.

Projections indicate that by 2020, 21,000 acres will be required for recreational uses. This amounts to approximately three times the area presently devoted to recreation. Increased demand will provide many opportunities for addition of recreational enterprises to existing farms and ranches to supplement family income. Many ranchers may shift entirely to recreation. A major part of increased recreation needs will be met by the 1.8 million acres of Federal lands.

The rapid growth of urbanized areas necessary for development of the oil shale industry will create the most dramatic shift in land and water use. It is estimated an additional 77,500 acres will be required for town sites, industrial lands, and other miscellaneous uses. Development of cities capable of housing the estimated population of 204,000 people will utilize much of this acreage.

Development of these cities will require a major shift in the fiscal structure of local government. Historically, the tendency to load increased costs of state and local government on property, and especially on real estate, has created difficult land use problems in rapidly developing rural areas. Advance planning of these developments, and particularly fiscal planning, by local government units could aid in smooth development of these cities and the transition from a dominantly rural-oriented to an industrial and urban area.

Potential Agricultural Production

Projections of livestock product requirements for the United States indicate that by 2020 we will need about three times the present production of beef and veal and about two times the present production of lamb or mutton. Since resources available for agricultural production in this Basin are primarily suited to livestock operations, production of livestock feed or forage was estimated for 2020 (table 21).

It is anticipated that agriculture in the future will continue to be primarily livestock enterprises. Rangeland grazing is estimated to have a potential to produce an additional 47,900 animal unit months of grazing, even though an estimated 90,200 acres of grazing land will move into other uses. This amounts to a 17 percent increase in grazing capacity, but even with good management this change will take place slowly. Proper use, rangeland seeding, fencing, controlling brush, and proper spacing of livestock salt and water will do much to increase grazing capacity of rangeland. However, increased feed or forage can be developed more effectively and rapidly by production on irrigated cropland.

By 2020 cropland grazing is estimated to furnish 96,800 animal unit months or 23 percent of total grazing. This will be a 48 percent increase from present conditions. At present, 25,600 acres of cropland (irrigated and dry farm) are producing an estimated 115,500 animal unit months of winter feed supplies. With improvements in water supplies and management it is estimated that by 2020 the 33,000 acres of cropland (irrigated and dry farm) will be capable of producing 205,200 animal unit months of winter feed supplies. In 1980

there will be an estimated 52,150 acres of irrigated cropland as compared with 47,600 acres in 2020. Approximately 35 percent of this acreage will be in irrigated pasture which will be of material assistance in reducing pressure on rangeland grazing.

Table 21.--Projected changes in livestock feed or forage production, White River Basin in Colorado, 1964 and 2020.

Source	1964		2020	
	Acres	AUM's feed or forage produced	Acres	AUM's feed or forage produced
Rangeland grazing	2,106,800	282,300	2,016,600	330,200
Cropland grazing				
Irrigated pasture and cropland grazing	35,200 [1]	48,100	47,600	86,000
Dry cropland and planted pastures [2]	27,700	17,400	18,000	10,800
Total cropland grazing		65,500		96,800
Cropland hay and forage	25,600	115,500	33,000	205,200
Total		463,300		632,200

[1] 1943-60 average cropland acres.
[2] Does not include summer fallow acreage.

Source: USDA Field Party

As previously mentioned this Basin provides yearlong feed and forage supplies for about 31,000 animal units of livestock plus an estimated 91,300 animal unit months of grazing for migratory livestock. The projected 632,200 animal unit months of feed and forage produced in 2020 would provide balanced feed and forage supplies for 50,000 animal units of domestic livestock and an additional 32,000 animal unit months for migratory livestock. Based on 1960 prices the gross returns from livestock and livestock products should be about 3.7 million dollars in 2020 as against the present average of about 2.7 million dollars.

Production of sawtimber, plywood and veneer logs, poles, posts, and other forest products should increase by 2020. The effects of the spruce bark beetle attack will disappear as new tree growth reaches merchantable size. The normal increase in population and economy of the Basin and state will develop demands and markets for substantial increases in forest products, part of which may be met from the resources of the Basin. There is a potential for establishment of processing plants for wood pulp and veneer.

Recreation

Increased demand for outdoor recreation facilities is a natural result of projected increases in national, regional, and local population. Individual types of recreation will have varying use dependent upon the availability of facilities. Some, such as hunting and fishing, may approach stabilization due to game and fish population reaching maximum yield. The Basin is able to meet the demand for some types of recreation activity but is practically undeveloped for others.

There are no national parks within the Basin and none are presently planned. However, the headquarters and main gateway to Dinosaur National Monument are located at Artesia (now Dinosaur). Access to this developing recreation area is thus provided to residents of the Basin and to the many tourists traveling U. S. Highway 40.

Rio Blanco County has purchased 539 acres of land 26 miles east of Meeker, which will be developed for recreation purposes by the county and the White River Recreation Association prior to 1980. Development will include campsites, picnic sites, parking areas, sanitary facilities, access roads and hiking trails. There will be hiking, horseback riding and stream fishing available within the park.

Present development of tourist accommodations is very modest. Increased demand will spur development, but development will probably occur at a rate less than the change in demand. Estimates of present and future demand for tourist and camping accommodations and deficiency in accommodations are shown in table 22.

Guest Ranches and Resorts

With more recreation demand, services and facilities offered by guest ranches and resorts are increasing rapidly. The Basin has a long history of guest ranch operations, but number and size of developments have been small. There is an almost unlimited area that can be developed for this purpose. About 60 miles of private land borders

fishing waters on the White River and its tributaries. These lands have easy access to nearby recreation areas on Federal, state, and private land, including the Flat Tops Primitive Area. Estimates of demand for guest ranch and resort accommodations are given in table 22.

Table 22.--Estimates of demand and development of motel, camping, guest ranch and resort accommodations, White River Basin in Colorado, 1980, 2000 and 2020.

Year	Demand	Capacity of development	Demand in excess of accommodations
	Visitor days	Visitor days	Visitor days
1980			
Motel	100,000	80,000	20,000
Camping	40,000	60,000	0
Guest ranch and resort	28,000	24,000	4,000
2000			
Motel	200,000	160,000	40,000
Camping	80,000	75,000	5,000
Guest ranch and resort	55,000	45,000	10,000
2020			
Motel	300,000	190,000	110,000
Camping	100,000	90,000	10,000
Guest ranch and resort	85,000	65,000	20,000

Source: USDA Field Party

Hunting

The Basin is noted for its big game hunting, and participation in this form of outdoor recreation has been increasing rapidly. Multiple licenses have attracted many additional hunters. As demand continues to increase, liberal seasons and multiple licenses will have to be reduced. Hunter numbers will reach a saturation level as big game harvest approaches the level of sustained production. Present big game hunting capacity is estimated at 200,000 hunter days annually. With projected changes in land use this would decrease to an estimated 190,000 hunter days in 2020 (table 23).

Table 23.--Estimates of demand and big game hunting capacity, White River Basin in Colorado, 1980, 2000, and 2020.

Year	Demand	Capacity of hunting	Demand in excess of available hunting
	Hunter days	Hunter days	Hunter days
1980	150,000	200,000	0
2000	300,000	192,000	108,000
2020	330,000	190,000	140,000

Source: USDA Field Party

Antelope hunting is of limited importance within the Basin. It is not widely available and is accordingly somewhat unique in the field of outdoor recreation. The limited antelope hunting will increase, particularly when deer and elk hunting reach a demand that cannot be satisfied. Alternative hunting will result when people cannot participate in their first choice. Small game hunting will increase.

Certain types of small game hunting, such as waterfowl, will increase slowly because of Federal regulation. The area is not on a continental flyway but local waterfowl will increase as water surface increases. Population and reproduction of upland game such as pheasant, sage grouse, sharptail grouse, blue grouse, chukar partridge, and cottontail rabbits, will determine seasons. Estimates of future small game hunting by hunter days is shown in table 24.

Table 24.--Estimated small game hunter days, White River Basin in Colorado, 1980, 2000, and 2020.

Year	Demand	Capacity of hunting	Demand in excess of available hunting
	Hunter days	Hunter days	Hunter days
1980	8,000	30,000	0
2000	60,000	30,000	30,000
2020	70,000	30,000	40,000

Source: USDA Field Party

Fishing

High altitude lakes such as Trappers, Marvine, Little Trappers and others will receive increased fishing pressure. Fishing days and bag limits will be regulated to spread availability of fish to as many fishermen

as possible. Road improvement to Trappers Lake will provide easier access and encourage increased usage, thus, increasing fishing pressure. Reservoir construction in connection with project development will provide additional lake fishing facilities. Fishing pressure will be dispersed to additional areas as construction of access roads makes more lakes and streams accessible. Fishing pressure is estimated in table 25.

Table 25.--Estimated fishing pressure, White River Basin in Colorado, 1980, 2000 and 2020.

Year	Demand	Fishing available	Demand in excess of available fishing
	Fishermen days	Fishermen days	Fishermen days
1980	200,000	150,000	50,000
2000	300,000	175,000	125,000
2020	400,000	200,000	200,000

Source: USDA Field Party

Private fishing lake and cabins

Stream fishing will be dependent upon the state hatchery program and capacity. Stream fishing has been good because the Colorado Department of Game, Fish, and Parks stock the streams several times each year, in accord with needs as shown by surveys of fishing pressure.

The Colorado Game, Fish, and Parks Commission has developed two lakes for public fishing: Rio Blanco Lake, an off-channel storage reservoir filled from the White River above the confluence of Piceance Creek, and Big Beaver Lake (Lake Avery) near Buford. Rio Blanco Lake will provide trout and warm water fishing. Big Beaver Lake will furnish ice fishing and summer trout fishing. There are many public fishing lakes in the national forest, including Flat Tops Primitive Area. Many private lakes have been developed for fishing. Lakes for other purposes have been stocked with fish. Fishing pressure on private ponds will increase as pressure grows on public streams and lakes.

Winter Sports

The Meeker Ski Club hopes to develop a ski site on national forest land east of Buford, Colorado (recreation map following page 68). A ski area in this vicinity would provide about 150 days of skiing each winter. Other prospective sites warrant consideration when the demand justifies. Development of ski areas would provide additional facilities to meet demands for tourists and resort accommodations during the off-season. Estimated demand for skiing is shown in table 26.

Table 26.--Estimated demand for skiing, White River Basin in Colorado, 1980, 2000, and 2020.

Year	Demand	Capacity of facilities	Unsatisfied demand
	Skier days	Skier days	Skier days
1980	6,500	4,000	2,500
2000	60,000	30,000	30,000
2020	70,000	50,000	20,000

Source: USDA Field Party

An ice skating area will be available on Big Beaver Lake (Lake Avery). The Colorado Game, Fish, and Parks Commission has sufficient land surrounding the lake to accommodate needed facilities. If the demand warrants, a lodge could be constructed to supplement outdoor facilities.

Potential Project Development

As used in this report, the term "potential project development" refers to projects concerned with water use rather than projects which are designed to increase or modify water yield of watersheds.

Several studies and reports have been made concerning proposed water use development projects in the Basin. Some of these projects warrant further detailed consideration. Others have become obsolete through changes in water use patterns and current developments. All known proposals were reviewed and those which appear to have a reasonable potential of being developed are shown on the Project Location Map, following page 86.

There are three major areas in the Basin where development will probably occur. Meeker and the surrounding area will be the center of agricultural development in connection with the Yellow Jacket project. The shale oil and related industries will be located in the Piceance Creek Basin. A small increase in agricultural production is expected near Rangely, together with development of the coal industry and related thermo-electric power generation.

Agricultural development in the past has been the largest user of water. An increase in irrigated acreage will probably continue through the period 1960-80. Thereafter, a slight decline, especially on short water supply lands in oil shale development areas, can be expected. Most irrigation water has been used on lands under privately owned canal and ditch systems. Some individual users have installed pumps to supply water for lands above existing canals and for bottomlands near the river where it has been impractical to maintain diversions for gravity systems. About 1000 acres have been developed under pump irrigation since 1960 and this water use has been included in projections for the 1960-80 period.

USBR Projects Under Investigation

The main stem of the White River is the water source for a large portion of the irrigated area. Most of these lands have a full water supply. Some smaller tributaries do not furnish an adequate late-season supply. Supplemental water for these lands, together with a full supply for new irrigated lands, will require reservoir storage. Two potential projects, "Yellow Jacket" and "Rangely", will provide storage and canal systems for some of the more desirable lands.

The proposed Yellow Jacket Reclamation project includes two reservoir sites, "Lost Park" and "Ripple Creek". These reservoirs will supply

water to lands on both sides of the White River above the existing network of canal systems near Meeker. A new canal system will serve lands adjacent to Curtis Creek, Coal Creek, and Little Beaver Creek on the north, and the upper reaches of Flag Creek and Sheep Creek on the south. In addition to irrigation, the reservoirs will provide water for municipal and industrial purposes.

The Rangely project, a multiple-purpose water and flood control project, is a potential development that might be accomplished as a privately financed development or under provisions of the Small Projects Act, Public Law 984. The reservoir site is on the main stem of the White River a few miles above Rangely. A dam at this site would provide protection against flooding caused by rapid snow melt or ice jams in the river valley. The town of Rangely, adjacent farm lands, and other improvements have suffered extensive damages from this source. The largest use of project water will be for industrial development and a proposed thermo-electric power generation plant. This would contribute to the development of local coal deposits. Municipal and industrial water would be provided, and water-based recreation facilities established. Irrigation water will be conveyed from the reservoir by a canal to lands on the south side of the river.

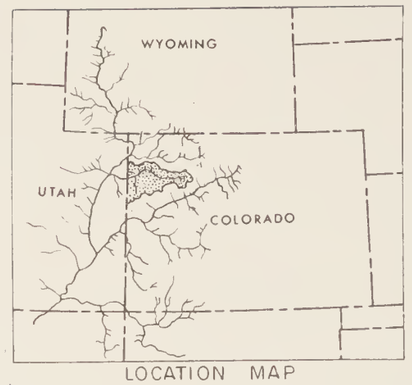
Industrial Development

The relationship between supply and demand of petroleum products in the United States has been of national interest for several decades. As liquid reserves decline and demand for petroleum continues to exceed national production and development of reserves, commercial production of oil shale will occur.

Production of crude shale oil requires very little water, but large quantities of water are needed in shale oil refining both as a process coolant and for generation of steam. The principal water source for oil shale development in the Piceance Basin (map following page 74) will probably be the South Fork of the White River which enters the main stem near Buford. Necessary reservoirs, diversions, canals, and related appurtenances for oil shale industries are speculative at this time.

Proposed Private Projects

Demand for outdoor recreation facilities continues to increase. There are increasing opportunities for land owners to meet this demand by developing income-producing recreation. Several farm and ranch units in the Basin have been operating recreational enterprises on a small



LOCATION MAP

KEY TO PROJECTS

USBR PROPOSED PROJECTS

I-L, I-R, & I-C, Yellow Jacket Project - multiple purpose water development
- I-L. Lost Creek reservoir site
- I-R Ripple Creek reservoir site
- I-C Proposed Yellow Jacket canal system

7. Rangely Project - multiple purpose water development & flood control (possible development under provisions of the Small Projects Act)

PROPOSED PRIVATE PROJECTS

2. Sweetbrier reservoir site - recreation water development

OPERATING PROJECTS

State of Colorado Department of Game, Fish & Parks
- 3. Big Beaver Lake - recreation development
- 6. Rio Blanco Lake - recreation development

8 Rangely Oil Field - water flood operations

USDA POTENTIAL PROJECTS

4. Miller Creek Ditch - rehabilitation
5. Strawberry Creek - flood prevention

LEGEND

- Cities and Towns
- Reservoir
- Potential Reservoir Site
- Canal
- Potential Canal
- Potential Tunnel
- Potential Siphon
- Basin Boundary
- State Line
- County Line

PROJECT LOCATION MAP

WHITE RIVER BASIN

IN COLORADO

Scale 10 0 10 20 Miles

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scale basis for years. The largest potential private enterprise is the Sweetbriar Reservoir site on the South Fork of White River. This reservoir would provide an estimated 600 acres of water surface for recreational purposes.

Operating Projects

Recently the Colorado Game, Fish and Parks Department completed construction of two recreation reservoirs. Big Beaver Lake (Lake Avery) is located near the confluence of Big Beaver Creek and White River. Rio Blanco Lake is an off-channel reservoir on the White River near the confluence of Piceance Creek. These reservoirs will provide additional water-based recreation facilities.

USDA Project Possibilities

The Department of Agriculture is interested in determining opportunities where Public Law 566 and/or other USDA authorities can contribute toward solution of water and related land resource problems of the Basin. Multiple-purpose watershed projects under Public Law 566 are an effective means by which rural and urban communities may cope with land and water problems. This type of project may include many purposes such as flood prevention, agricultural water management, municipal and industrial water supply, recreation, and fish and wildlife development.

With development of the Basin, the conservation of land and water resources by means of project action will become increasingly important. In the past the costs of flood prevention have not been justifiable in relation to benefits. The Strawberry Creek valley is a probable location of urbanization in conjunction with the oil shale development. This area is subject to periodic flooding and if urbanized would be a potential USDA project, possibly a Public Law 566 multiple-purpose watershed project. In view of the expected increase in population, potential urban areas such as Strawberry Creek, Flag Creek, Sheep Creek, and Piceance Creek will require land stabilization and water control structures to handle an increase in storm runoff.

Several smaller land and water development opportunities exist in the Basin. These are generally of a type that could be assisted through use of USDA programs and authorities other than Public Law 566. Assistance could include cost-sharing through the Agricultural Stabilization and Conservation Service pooling agreements, Farmers Home Administration group water-facility loans, and technical assistance to group enterprises through Soil Conservation Service assistance to

Soil Conservation Districts. As an example, stream bank stabilization of the White River main stem is a continuing conservation practice need. Even though this practice is carried on by individual land owners, benefits are realized on various reaches along the river. The Miller Creek Ditch is being enlarged and rehabilitated to better serve its water users. Several other irrigation systems are in need of similar rehabilitation. Water measurement is an essential item in all water use programs. A more reliable system of water measuring devices is needed in existing canals and ditches. As demand for water increases an accurate accounting of water supplies will become necessary for management of the resource.

Streambank stabilization on the White River

The basic significance of water resources to the economy and land use has resulted in extensive investigations by major water resource agencies having responsibilities within the Basin. As a result, larger water supply projects, and smaller projects having recognized economic feasibility, have been scheduled for detailed planning or construction. Flood prevention or protection is incorporated to a degree in all such projects.

Flood problems and damages are relatively minor in most of the Basin. Agricultural land use patterns are such that the ordinary floods cause little damage to agricultural lands and improvements, and may in fact constitute a part of the irrigation water supply for meadows and pastures.

There are limited areas with measurable flood damage. The survey has disclosed none where flood prevention alone, under present conditions, is economically feasible under the provisions of Public Law 566.

POTENTIAL WATER USE

Projections of potential developments and related water depletions were made for 1960-1980, 1980-2000, and 2000-2020. With potential developments, estimated average annual depletion by 2020 is 214,100 acre-feet. This is more than five and one-half times the average annual amount of water consumptively used during the 1943-60 period. The water supply of the Basin during the study period would be sufficient to support the developments outlined in this report. Any additional developments or export of water would require substantial carry-over storage.

It is beyond the scope of this report to plan or design operational aspects of proposed developments. Within-Basin depletions, as described here, are consumptive use estimates and do not indicate diversion and storage requirements or conveyance losses.

Precipitation and runoff are highly variable and are governed primarily by chance processes. Investigations have not been made in sufficient detail to analyze or make probability forecasts of future annual flows. Data presented are based on assumptions relative to the 1943-60 period.

Estimates of net consumptive use by crops were based on 1943-60 climatic records and an estimation of probable future irrigated crop acreage and distribution. Adjustments were made for expected variations in adequacy of water supply. Other depletive uses of water were estimated separately. These included consumptive use on noncrop water-using areas incidental to irrigation development, use by riparian and nonbeneficial phreatophytic vegetation, evaporation from reservoirs, industrial use, municipal and domestic use.

Changes in Water Use

Considering potential developments, there will be a concomitant change in distribution of water use among the several types of use, as compared with that of the 1943-60 period.

An increase of 48 percent in irrigated crop acreage is the major factor in the estimated increase of consumptive use of irrigation water. Changes in cropping pattern will have little effect on overall consumptive use of water. Most irrigation developments and related increases in consumptive use are expected to occur during 1960-80. A gradual decline in agricultural use of water is expected in the succeeding periods as a result of oil shale development. Projected use of water for agricultural purposes is 70 percent greater by 2020 than during 1943-60 (table 27).

Consumptive use by nonbeneficial phreatophytes, riparian vegetation, seeped lands, and incidental areas varies in accordance with available supply. Increase in irrigated acreage and an improved water supply for presently irrigated lands will provide more opportunities for nonbeneficial consumptive use. Conversely, an overall reduction in nonbeneficial use of water is anticipated as a result of the impact of shale oil development. Nonbeneficial consumptive water use is expected in 2020 to be less than 60 percent of the estimated use during 1943-60.

The major use of water will be in conjunction with oil shale development even though the increase of water on irrigated lands is considerable. More than 55 percent of projected consumptive use of water for the period 2000-2020 will result from projected industrial, municipal, and domestic uses. Much of the data related to water use for the oil shale industry is based on the report "Water Requirements for Oil Shale", prepared for the State of Colorado by Cameron and Jones, Inc. Initiation of operational phases of the industry is expected to occur subsequent to 1970 and full production attained within a 20-year development period. Estimated water depletion by the industry (excluding municipal use) in 2000 is about 95,000 acre-feet annually.

Current annual water depletion by the Rangely oil field water-flood operation is about 9,400 acre-feet. This use is expected to decline and should be negligible by 1980.

Industrial use of water from the proposed Rangely project would be in connection with a thermal power plant planned near Rangely. Information regarding this power development is not complete but annual consumptive use is estimated at 20,000 to 30,000 acre-feet.

WATER SUPPLY SUMMARY

Estimated average annual water supply and basin drainage for the periods 1943-60 and with projected developments by 1980, 2000 and 2020 are summarized in table 27.

Table 27.--Average annual water supply and river basin discharge, White River Basin in Colorado, 1943-60 and with projected developments by 1980, 2000, and 2020.

Item	1943-60	1980	2000	2020
	Acre-feet	Acre-feet	Acre-feet	Acre-feet
Irrigated crops [1] (Net consumptive use) [2]	29,300	53,500	51,900	49,900
Riparian vegetation, nonbeneficial phreatophytes, seeped lands, and incidental areas [3] (net consumptive use) [2]	7,300	6,800	5,100	4,200
Industrial, municipal, domestic and livestock use, and reservoir evaporation	1,800	37,400	157,700	160,000
Total depletion	38,400	97,700	214,700	214,100
Total undepleted supply (yield) [4]	525,400	525,400	525,400	525,400
River Basin discharge [4] (Supply minus depletion)	487,000	427,700	310,700	311,300

[1] Estimated irrigated acreage: 1943-60 = 35,200 acres, 1980 = 52,150 acres, 2000 = 50,150 acres, 2020 = 47,600 acres.

[2] Net consumptive use is the amount of water, excluding effective precipitation, used in evaporation and transpiration.

[3] Estimates of water depletion resulting from riparian vegetation and nonbeneficial phreatophytes may in some instances include consumptive water use due tc natural conditions that are impossible to separately identify and differentiate from man-related development.

[4] This data is relative to the discharge for the 1943-60 period and does not represent a forecast of future annual yields and discharges.

Source: USDA Field Party

With many water resource developments, the supply is far removed from the point of use. Distances vary from a few feet to many miles. Unlike other resources, water generally is used and reused many times.

Water from melting snow is the primary source of Basin water supplies. Since the annual spring snowmelt runoff is a varying factor, both in time and amount, additional storage facilities will be necessary to meet increased demands. Storage is twofold in purpose. First, water can be regulated and controlled in accordance with variations in need; and second, it can be carried over for use during periods of deficient supply.

As in the past, a large amount of water will be used on irrigated lands. However, industry, together with related population increases and their water requirements, will consume a higher percentage of the supply.

The development, equitable distribution, use, and disposal of water resources introduces many complex problems including those relating to both quantity and quality. Successful development of potential projects will require a high degree of water management efficiency. Since water is the essential resource common to potential project developments, an overall plan of development is of utmost importance.

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